# TM 5-228

WAR DEPARTMENT TECHNICAL MANUAL

# ENGINEER FOUNDRY



*AR DEPARTMENT • 6 SEPTEMBER 1944*

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For explanation of symbols, see FM 21–6.

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## SECTION I
# GENERAL

**1. PURPOSE.** This manual is a guide for engineer foundry units. It is written to serve as a reference during training and as a source of information in the field. Terms not explained in the text are defined in appendix I; reference information is given in appendices II, III, IV, and V.

**2. MISSION OF ENGINEER FOUNDRY.** The mission of the engineer foundry (figs. 1 and 2) is to make metal castings which cannot normally be fabricated in any other way (fig. 3) and to replace broken, worn, or damaged parts not readily obtainable through usual supply channels.

**3. OPERATIONS OF ENGINEER FOUNDRY.** A general picture of foundry operations will make it easier to follow the detailed discussion in the following chapters. The first step in making a casting is to prepare a pattern. This pattern is placed in a split form called a flask and sand is packed around it. The mold thus formed is normally in two main sections, the bottom or drag and the top or cope. Passages are made through the mold so molten metal can be poured in. The cope is then raised, the pattern taken out, and the mold closed again. Molten metal is poured in; it fills the space left by the pattern and hardens in the shape of the pattern. (See fig. 4.) The resulting casting is cleaned and finished, and is ready for use.

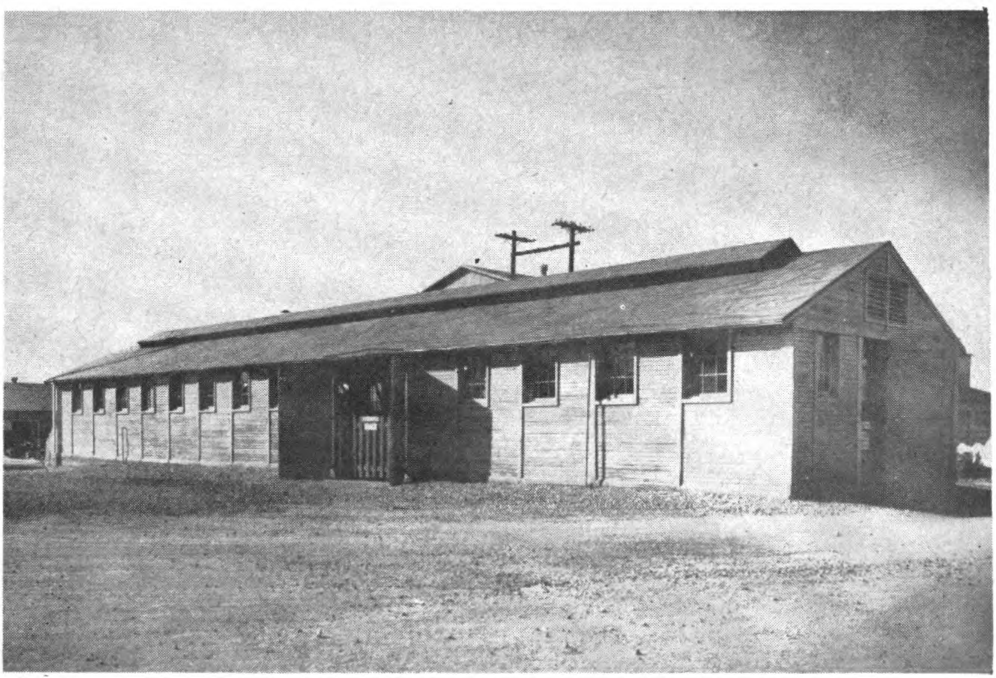

*Figure 1. Typical engineer foundry, exterior view.*

*Figure 2. Typical engineer foundry, interior view.*

*Figure 3. Pouring steel castings in an engineer foundry.*

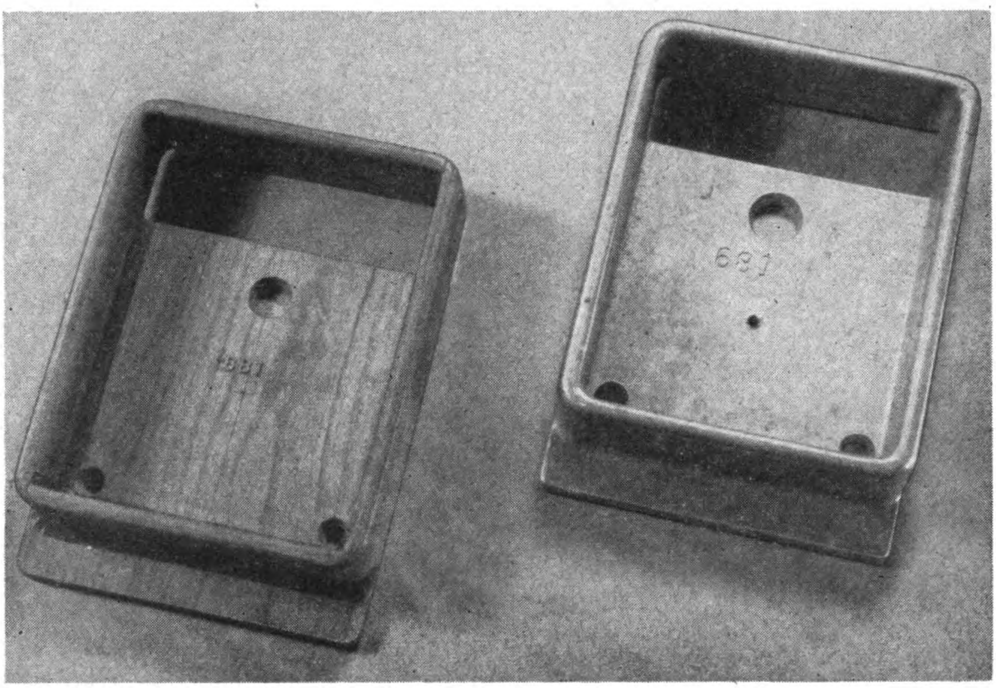

*Figure 4. Wood pattern (left) and metal casting produced from it (right).*

## SECTION II
# PATTERN MAKING

**4. TYPES OF PATTERNS.** Patterns are wood, metal, or built-up broken parts. They must be smooth, free from sharp corners, and designed so they can be easily removed from the mold. (See fig. 5.) A pattern may be made in one or more sections, depending on its shape and the molding problems involved. A pattern made in more than one section is called a parted or split pattern.

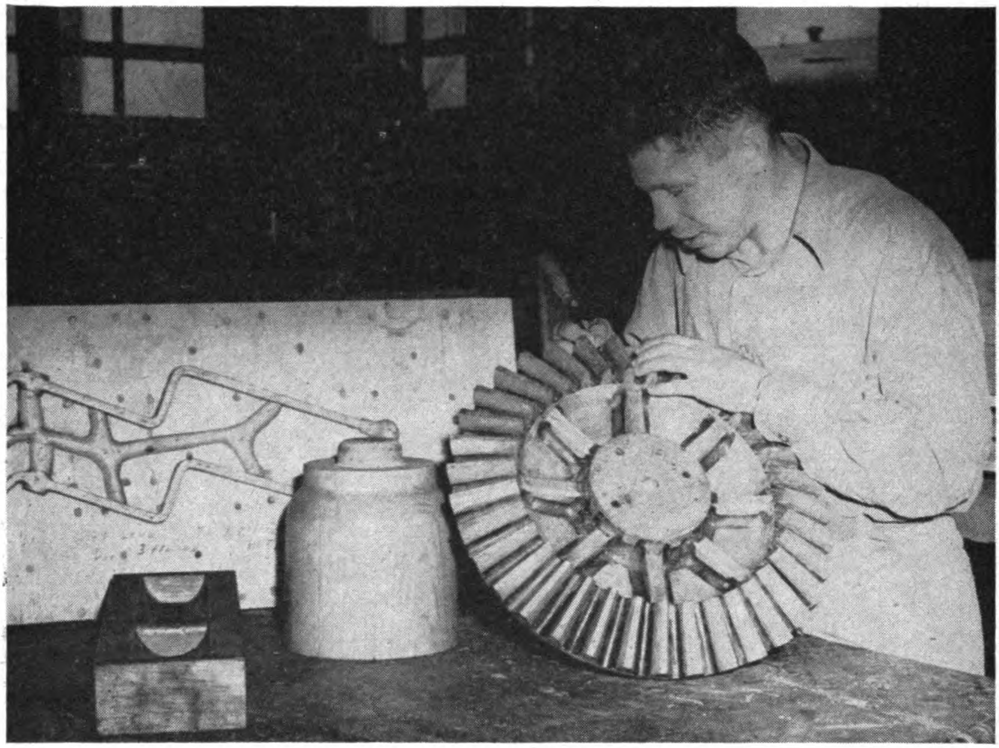

*Figure 5. Pattern maker finishing pinion-gear pattern. In background, gear-shift-lever pattern on match plate.*

**a. Wood patterns.** Wood patterns are usually prepared of close-grained hardwoods such as cherry or mahogany. These woods withstand the rough treatment of molding and the moisture in the sand. However, if they are not available, wood from packing cases or crates can be used. To prevent patterns shrinking or warping, the wood must be dry and patterns should be stored in a dry place.

**b. Metal patterns.** Metal patterns are used only when a large number of castings are to be made from the same pattern. They are not normally justified in engineer foundry work since most patterns are used only once.

**c. Worn or broken parts.** Worn or broken parts are frequently used as patterns. They must first be built up with shellac, beeswax, paper, or wood to allow for shrinkage (fig. 6) (see par. 8).

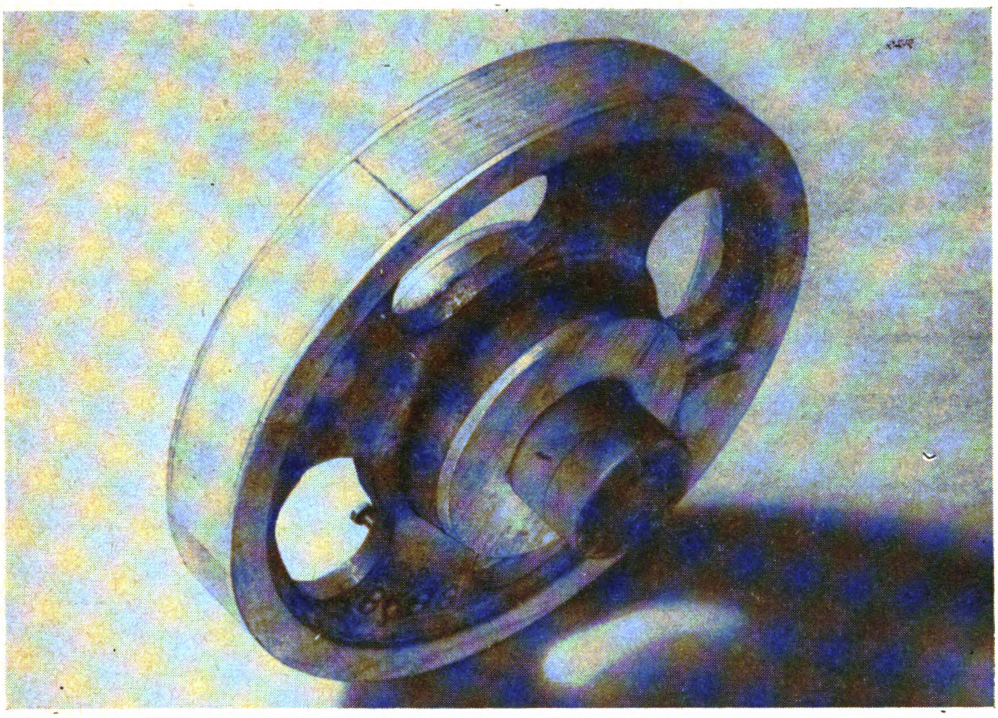

*Figure 6. Worn part built up with wood.*

**5. BLUEPRINT READING.** A pattern maker must be an expert blueprint reader since patterns are made from drawings as well as from broken or worn parts. He must be able to visualize the casting and plan his pattern so it can be cast easily.

**6. PARTING LINE.** A mold is usually made in two parts separated by a parting line. Unless the pattern maker locates the parting line properly on the pattern, the pattern cannot be removed without damaging the mold. The part of the pattern or mold above the parting line is the cope; the part below, the drag.

**7. DRAFT.** Patterns are designed so they can be removed from the mold without damaging it. This is accomplished by giving them draft: sloping the sides so the clearance between pattern and mold increases as the pattern is lifted out. The draft allowance is usually 1/32 inch for each 2 inches of draw. This means that clearance on each side between pattern and mold increases 1/32 inch for every 2 inches the pattern is raised. (See fig. 7.)

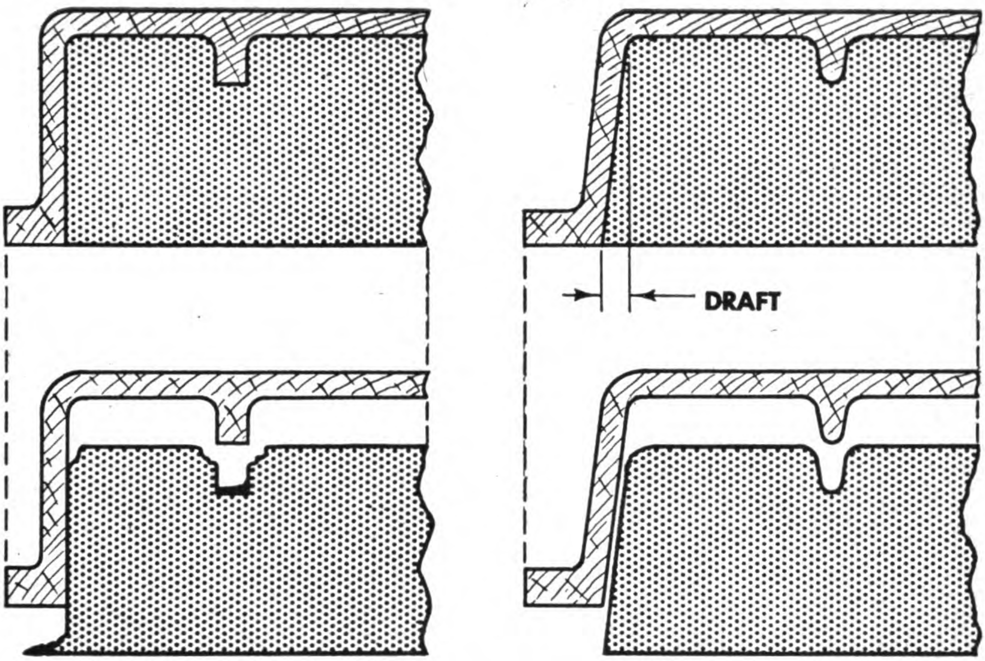


*Figure 7. Pattern showing draft allowance to permit removal without damaging mold.*

**8. SHRINKAGE.** Metals contract while cooling, so a casting is always smaller than its pattern. The pattern must therefore be designed to allow for this shrinkage. Shrinkage allowance for different metals varies with their rates of contraction, as follows:

| *Metal* | *Approximate shrinkage allowance* |
|---|---|
| Cast iron | 1/8 inch per foot |
| Bronze | 3/16 inch per foot |
| Steel | 1/4 inch per foot |

Thus, if a finished steel casting is to be 12 inches long, the pattern must be 12 1/4 inches long. The shrinkage rule, a scale for measuring patterns, is designed with its graduations enlarged to compensate for shrinkage. This eliminates any special computations. In making a pattern for a steel casting 12 inches long, the shrinkage rule is used to measure the pattern; the 12-inch graduation on the rule actually represents 12 1/4 inches, the required length.

**9. TOOLS.** Special tools are used to make wood patterns, and there is a correct tool for every part of the job. It is important to know which tool to use for each operation. It is even more important to keep the tools in proper working condition at all times.

**10. PAINTING.** Wood patterns are protected with two coats of shellac varnish. In addition, they are colored for identification as follows:

Black: to be left unfinished.
Red: to be machined.

Red stripes on yellow: loose pieces.
Black stripes on yellow: stop-off's.

**11. NUMBERING.** Patterns in storage are identified with castings by numbering them. (See fig. 4.) Prefix letters are used to indicate the metal for which the pattern was designed; for example, *B* for bronze, *S* for steel, *C* for cast iron. The same pattern cannot be used for different metals, because of the differences in shrinkage allowance and because the metal to be used frequently influences the way in which a part can be cast. The numbers and letters are made on the pattern so they will be reproduced on the casting.

## SECTION III
# PREPARING MOLD

**12. GENERAL.** The quality of a casting depends on a number of factors: the sand used for the mold; the manner in which the mold is prepared; how the metal is melted and poured; and the way the casting is treated. Each of these is discussed in detail below.

**13. SAND. a. Properties required.** (1) A good foundry sand has the following physical characteristics:

(*a*) Plasticity, so it can be formed in the desired shape.

(*b*) Cohesiveness, so it will hold that shape.

(*c*) Refractoriness, so it will not burn or melt when molten metal is poured into it.

(*d*) Porosity, so gases formed in the process can pass through it.

(2) Some natural sands possess all these qualities. All sands used for molds must have the correct moisture content; adding water for this purpose is called tempering. (See fig. 8.)

**b. Testing.** There are many mechanical devices for testing foundry sand. However, an experienced molder can judge its quality by feeling it and by squeezing a sample in his hand and breaking it. Foundry sand becomes darker

*Figure 8. Tempered sand heap ready for molding.*

in color through continued use. This does not indicate that it is no longer satisfactory. It should be used, regardless of color, as long as it meets the test for strength and fineness.

**c. Types of sands.** Metals and alloys with different melting points and other differing physical properties require different types of foundry sands. If natural sands do not meet the requirements, synthetic sands can be prepared by adding clay (bentonite) as a binder to washed silica sand.

(1) *For aluminum and bronze.* Natural bonded sands can be used to cast aluminum and bronze. However, the sand grains must be fine to give the casting a smooth surface.

(2) *Cast iron.* If a suitable facing sand is provided, natural bonded sands can also be used for cast iron. Facing sand can be prepared as follows: mix equal quantities of old and new sand; add 1 part sea coal to 8 parts sand and add 3 percent to 4 percent bentonite by weight. Sea coal gives the casting a smooth surface by forming a gas film between metal and mold; this film also prevents fuzing of sand and casting. As the sea coal burns, it forms small openings in the mold through which gases escape.

(3) *Steel.* Special mixtures of sand must be used for steel because of the high temperatures at which it is cast. Sand in direct contact with the casting (facing sand) is subjected to the highest temperature and must be highly refractory. The balance of the mold may be filled with previously used sand (heap sand).

(*a*) A good sand for steel castings can be prepared by mixing 90 parts silica sand, 10 parts bentonite, and 4 parts water.

(*b*) A suitable facing sand is made as follows: add 1 part silica sand to 2 parts heap sand containing 10 percent bentonite; to 92 parts of the above mix, add 8 parts bentonite and 4 percent water by weight. This facing must be thoroughly mixed to eliminate balls of clay which might come in contact with the casting and form small hard spots. The temper of facing sand must be watched closely, since synthetic sands tend to lose their moisture much more rapidly than natural sands.

**14. FLASKS.** A flask acts as a box to hold the sand while it is packed (rammed) around the pattern. Flasks also are usually divided into a cope and a drag. There are many types of wood and metal flasks.

**a.** The snap flask, tapered or straight, is standard in the shop equipment of foundry units. (See fig. 9.)

**b.** The tapered flask is constructed so it can be removed from the mold by merely lifting it.

**c.** The straight flask is hinged so it opens at the sides for removal from the mold.

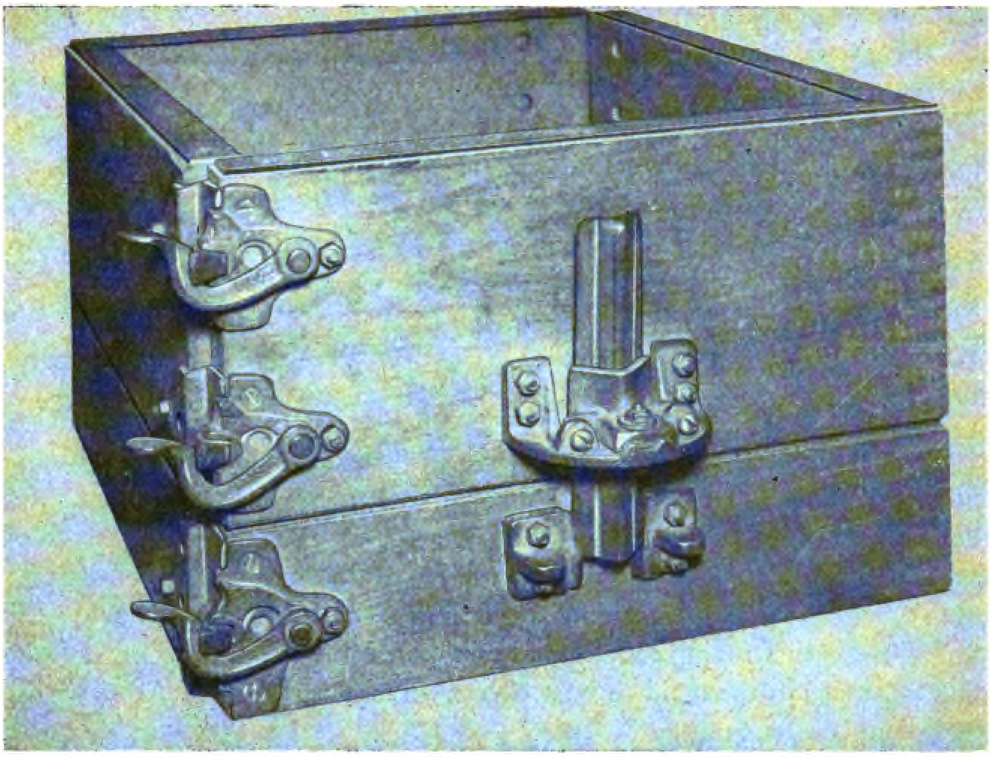

*Figure 9. Tapered snap flask.*

**15. MOLD. a. General.** One of the most important steps in forming the mold (fig. 10) is ramming the sand to the proper density, firm but not solid; this comes only with practice. The quality and strength of the casting is affected by how hard the sand is rammed. Heavy castings must be rammed harder than light castings; synthetic sands harder than natural bonded sands. If the sand is rammed too hard, it does not permit the gases to escape.

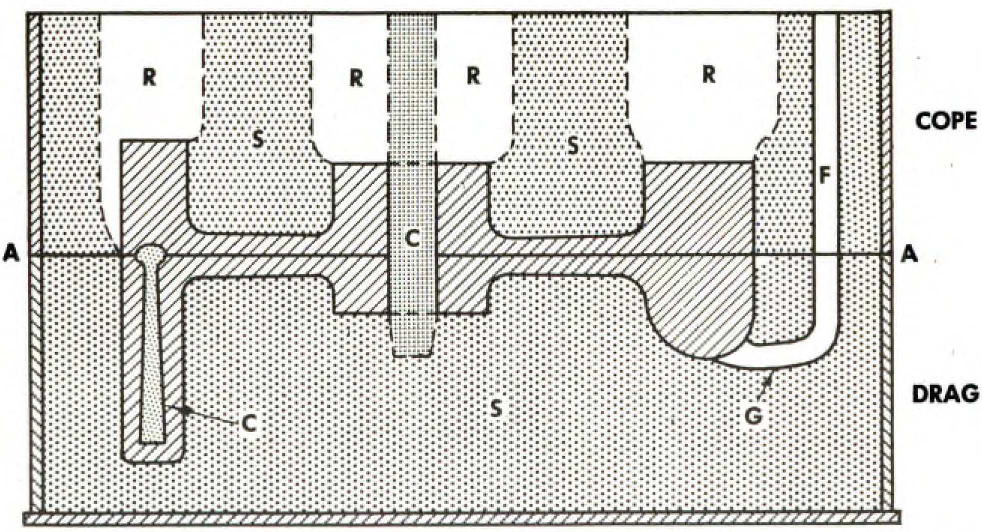


*Figure 10. Cross section of mold showing component parts. AA–parting line; R–riser; C–cone; F–runner or sprue; G–gate; S–sand*

**b. Sprues, gates, and risers.** (1) A sprue is an opening in the cope or intermediate parts of the mold for entry of the molten metal. The passage through which the metal flows from sprue to casting is called a gate. A number of sprues and gates may be provided so the metal can enter the casting at more than one point. Sprues and gates must be located so the molten metal reaches all portions of the casting. Otherwise the cooling metal may block off the flow to other portions of the casting. Gates are formed with a special tool, a gate cutter, or with a gate stick. The latter is a stick placed between sprue and pattern while the mold is being rammed; when removed it leaves a channel in the mold.

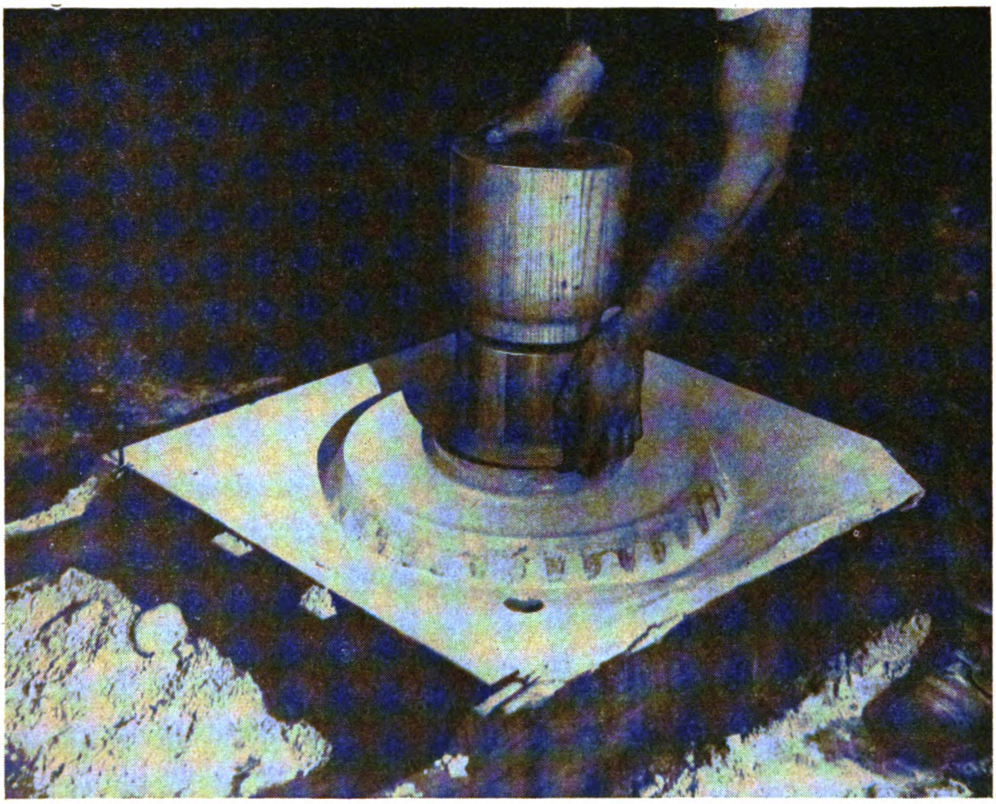

*Figure 11. Placing riser and hub portion of pattern preparatory to placing cope of flask.*

(2) A riser (fig. 11), also called a head or shrinkhead, is a gate formed over a heavy section of the casting. The excess metal which runs up into the riser acts as a feeder to supply additional metal while the casting cools, thus preventing shrinkage cavities in the casting.

**c. Drag.** The drag of the mold is prepared as shown in figures 12 to 17. Sand is rammed around the pattern until the flask is filled. The bottom is prepared with a trowel or leveling stick to remove excess sand. (See fig. 18.) Sand is then riddled on to provide a firm bearing for the drag on the bottom board.

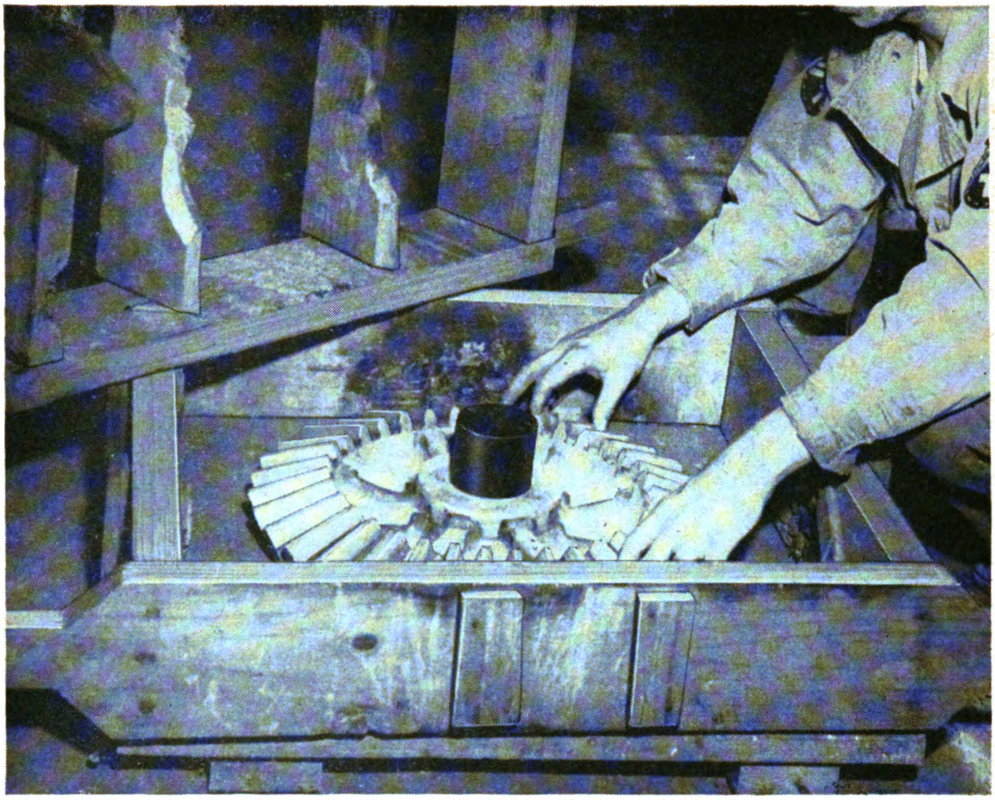

*Figure 12. Placing pinion-gear pattern in drag on follow board. Flask made of scrap lumber.*

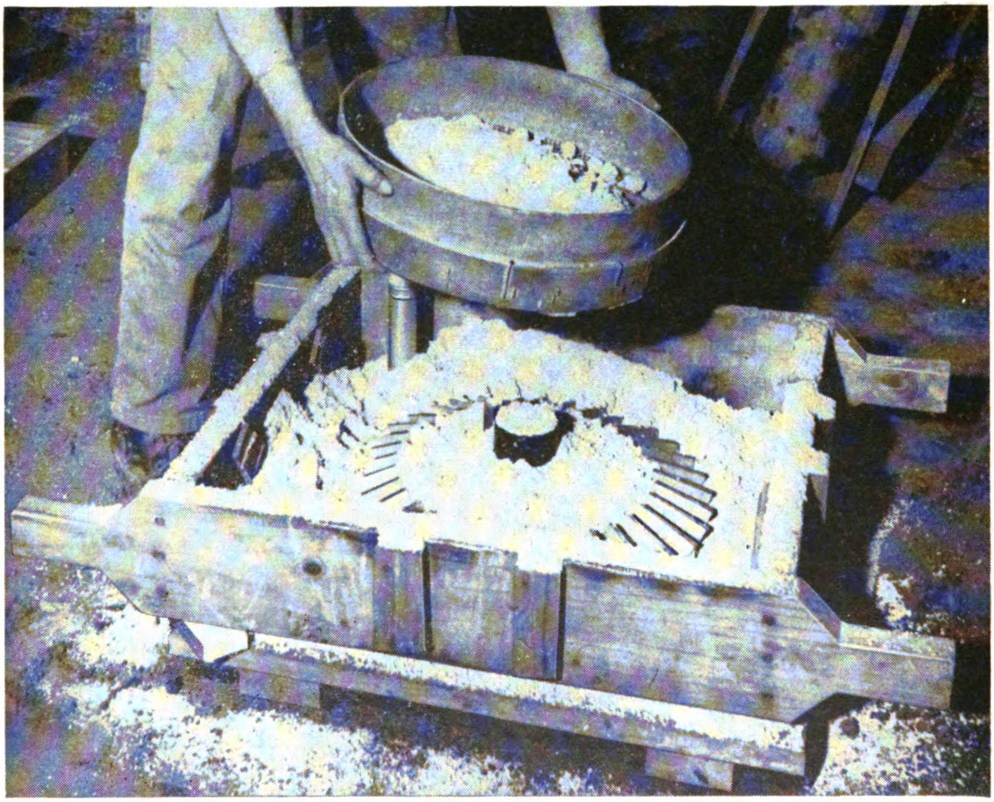

*Figure 13. Riddling sand onto pattern. Note gate stick in corner for bottom pouring.*

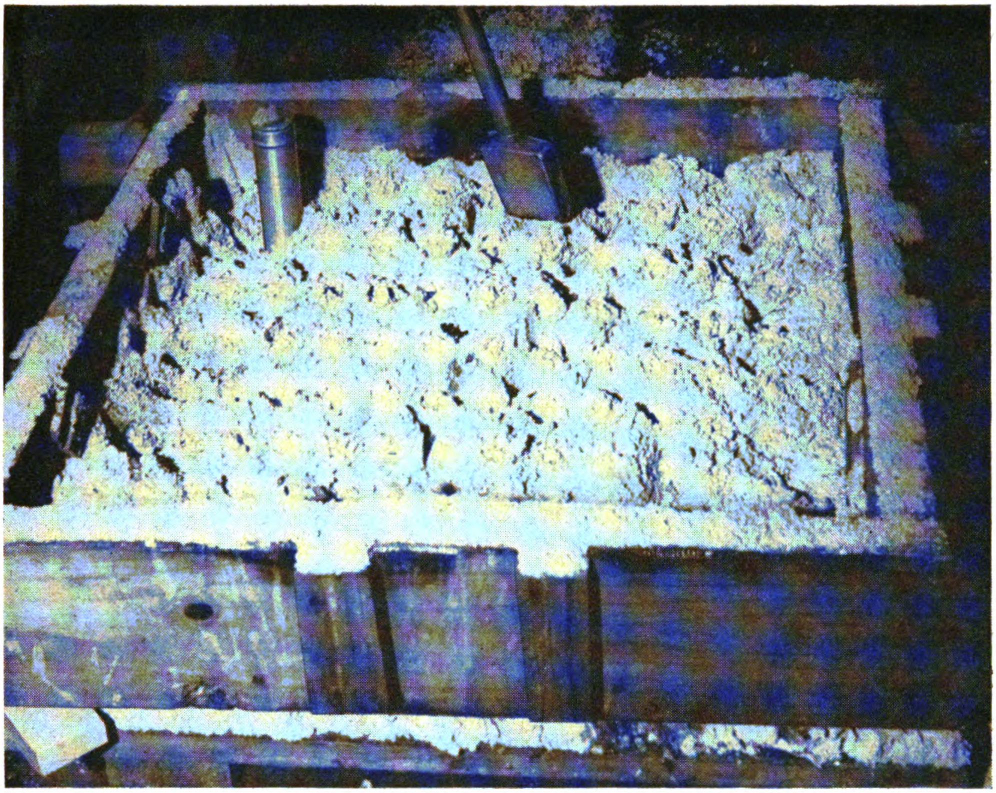

*Figure 14. Peening drag facing sand around pattern.*

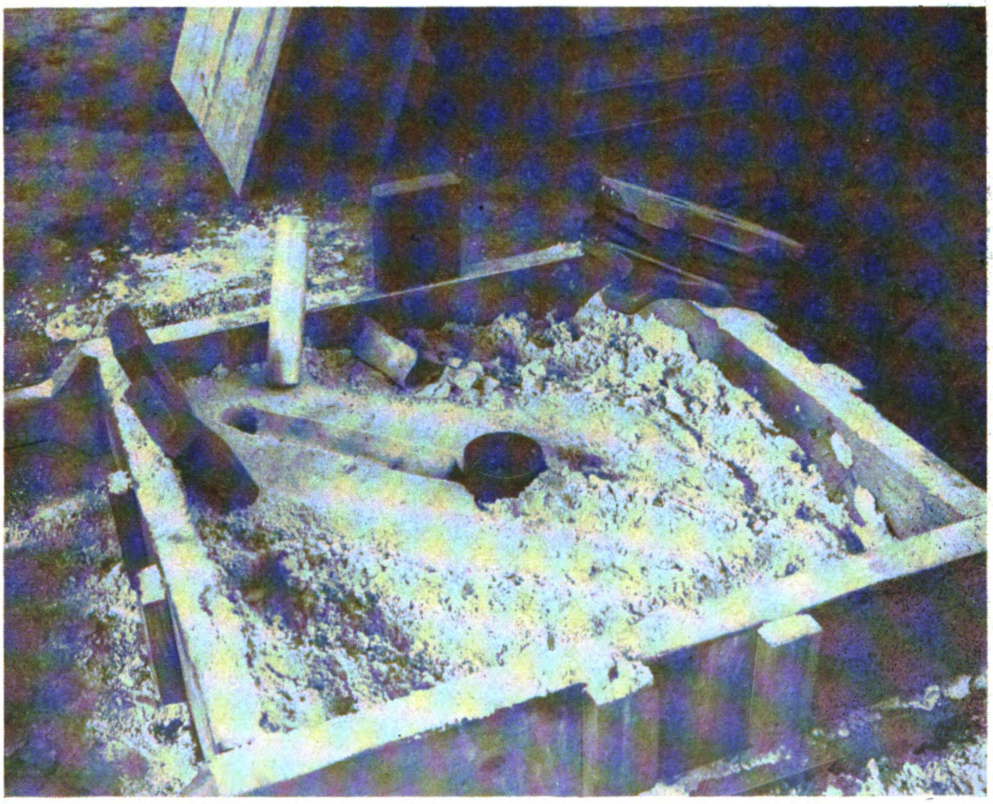

*Figure 15. Drag after cutting bottom-pour gate.*

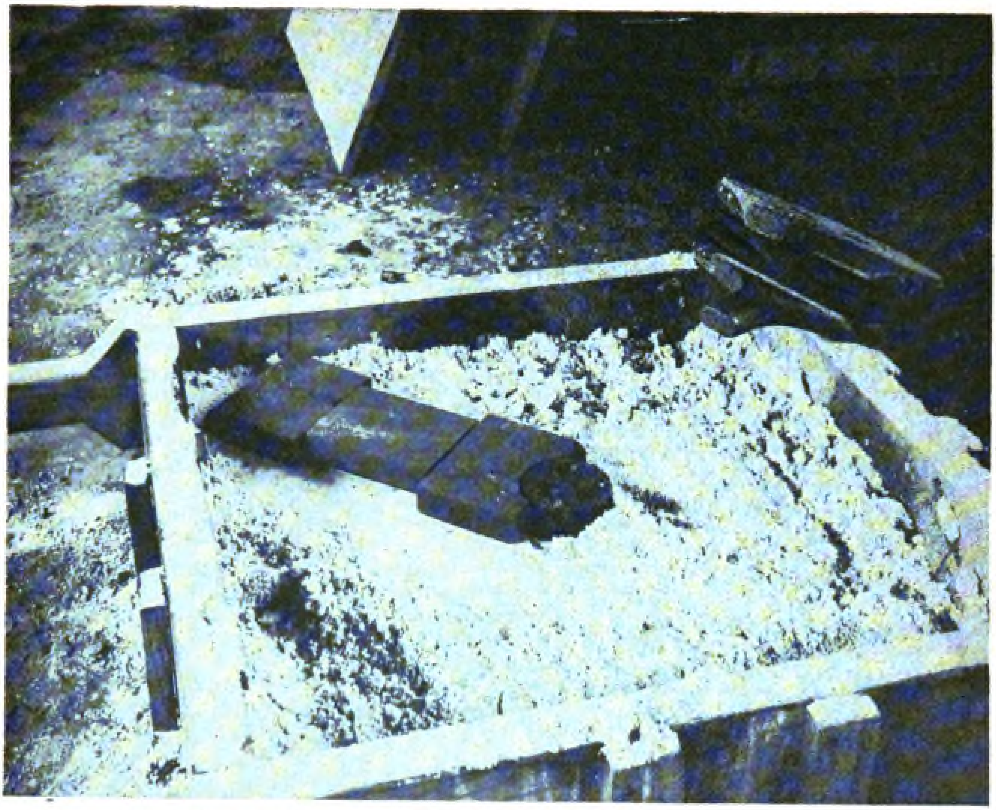

*Figure 16. Cover cores in place for bottom-pour gate.*

*Figure 17. Butting off drag backing sand. Note dark color.*

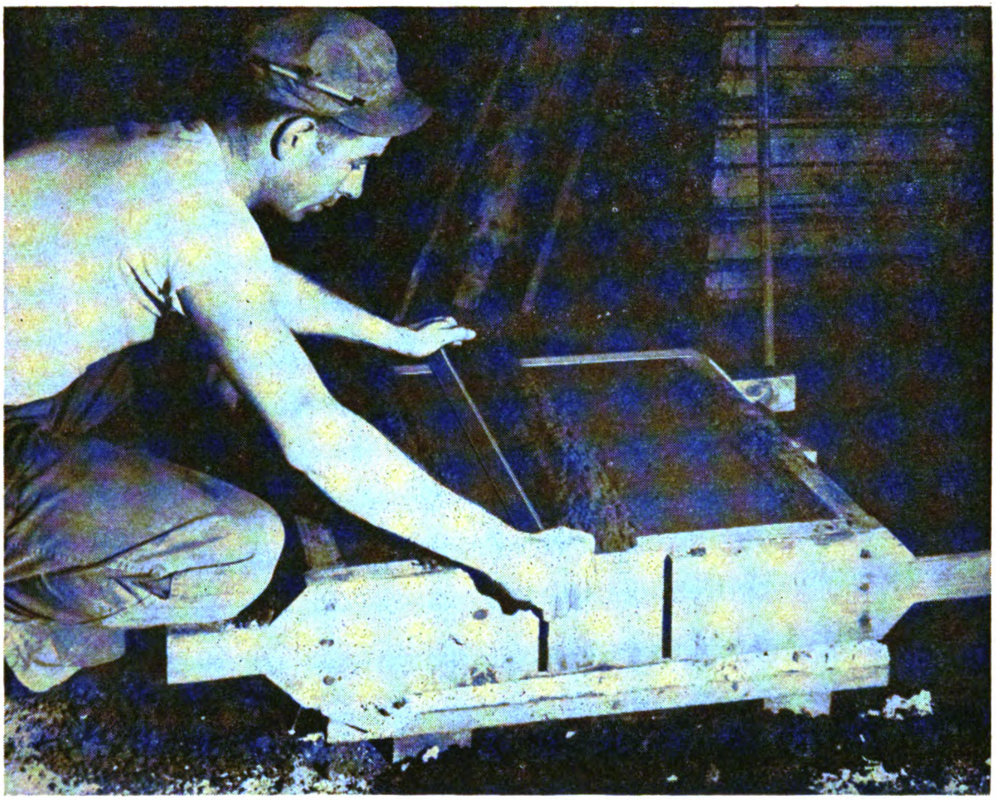

*Figure 18. Leveling (striking off) drag.*

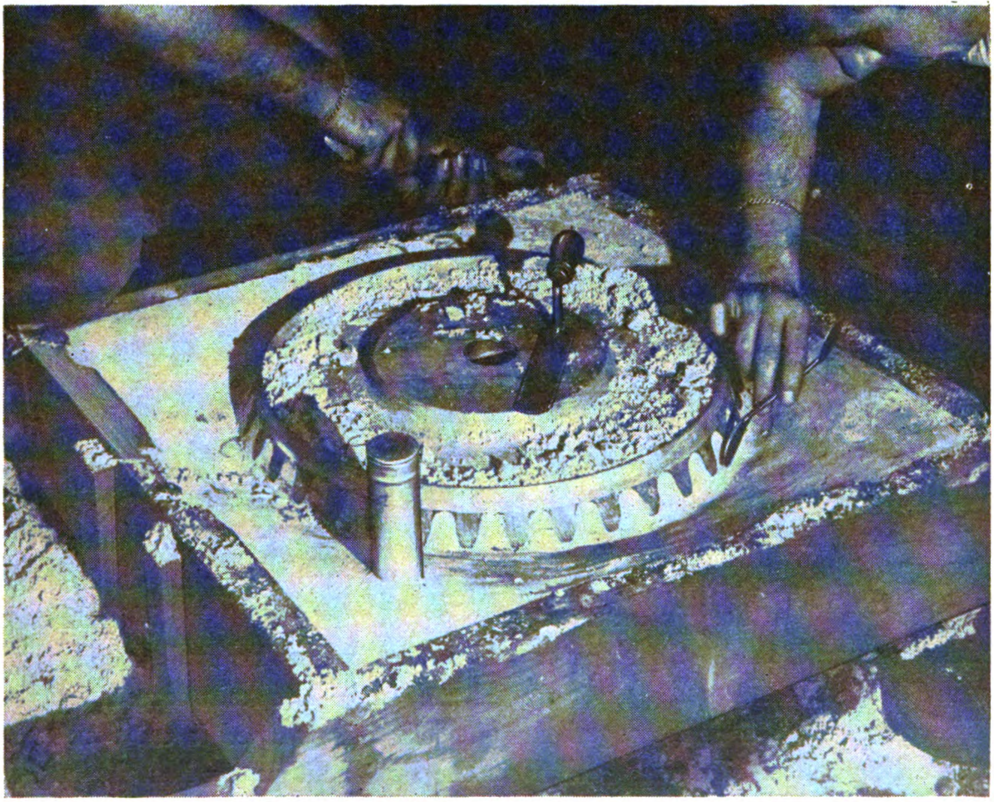

*Figure 19. Forming parting line with double-ender, slick, and spoon. Note irregular parting line as compared with that in figure 10.*

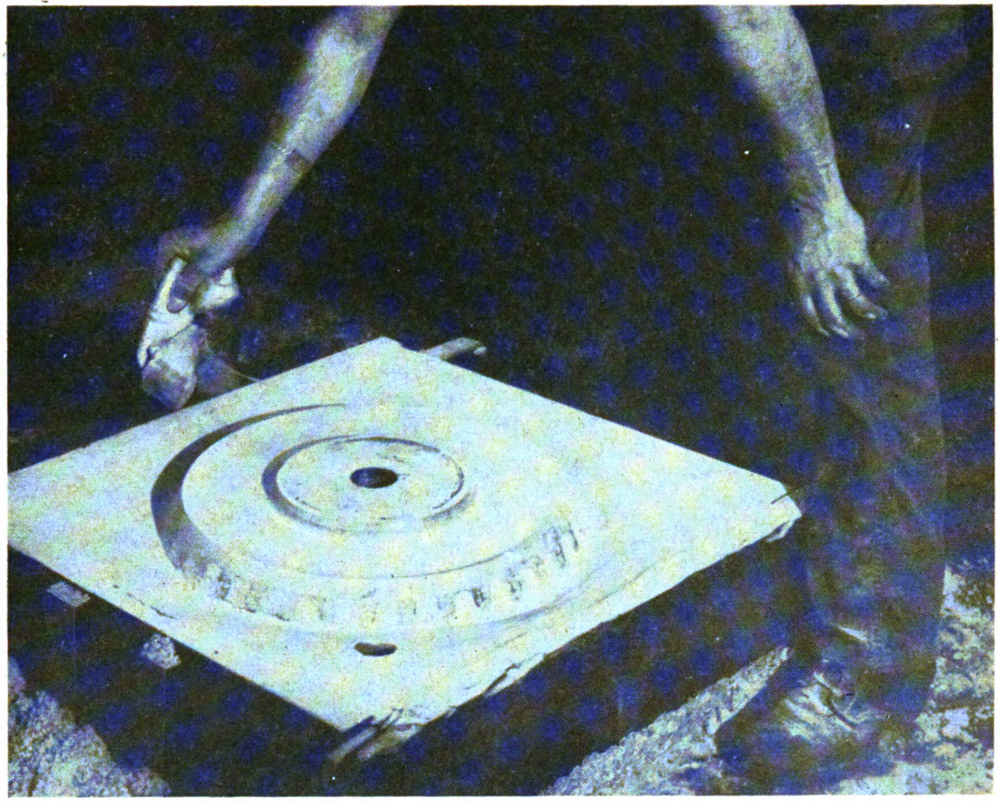

*Figure 20. Dusting parting flour on drag.*

**d. Parting.** A parting must be provided between drag and cope of the mold so they will not stick together. The parting is made by turning the drag over, forming a parting line (fig. 19), and shaking a parting flour over the pattern and the exposed sand of the drag. (See fig. 20.) The parting flour forms a nonbinding film between the two sections of the mold.

**e. Cope.** The cope is prepared as shown in figures 21 and 22. Passages for the flow of metal are provided at the top, sides, or bottom, depending on the design of the casting.

**f. Venting.** Vents are provided in the mold to permit gases to escape. They are made by running a blunt-ended wire completely through the mold to within 1 inch of the casting. The wire ends are blunt so the ends of the vents will not be too small.

**g. Cleaning mold.** The cope is now lifted off the drag and the pattern taken out. (See figs. 23 and 24.) All loose sand is removed from the cavity.

**h. Cores.** (1) Cores are used where there are to be cavities in the casting; they may be used in a number of ways. Cores are made of baked, specially prepared sand. A satisfactory oil-sand core can be made as follows: mix 100 parts sand to 2 parts core oil; add water to obtain correct temper. The water holds the sand together while it is being shaped in the core mold (core box). The oil forms a film on the sand particles; when the core is baked the film hardens and acts as a binder.

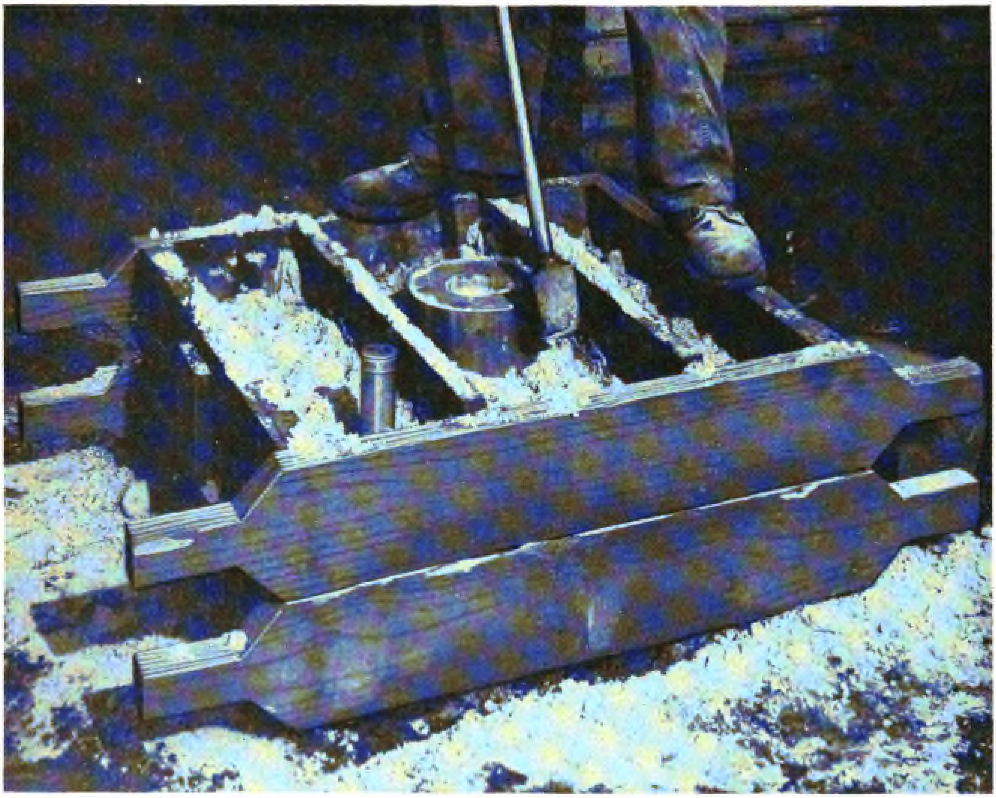

*Figure 21. Peening facing sand in the cope. Note gate stick in place.*

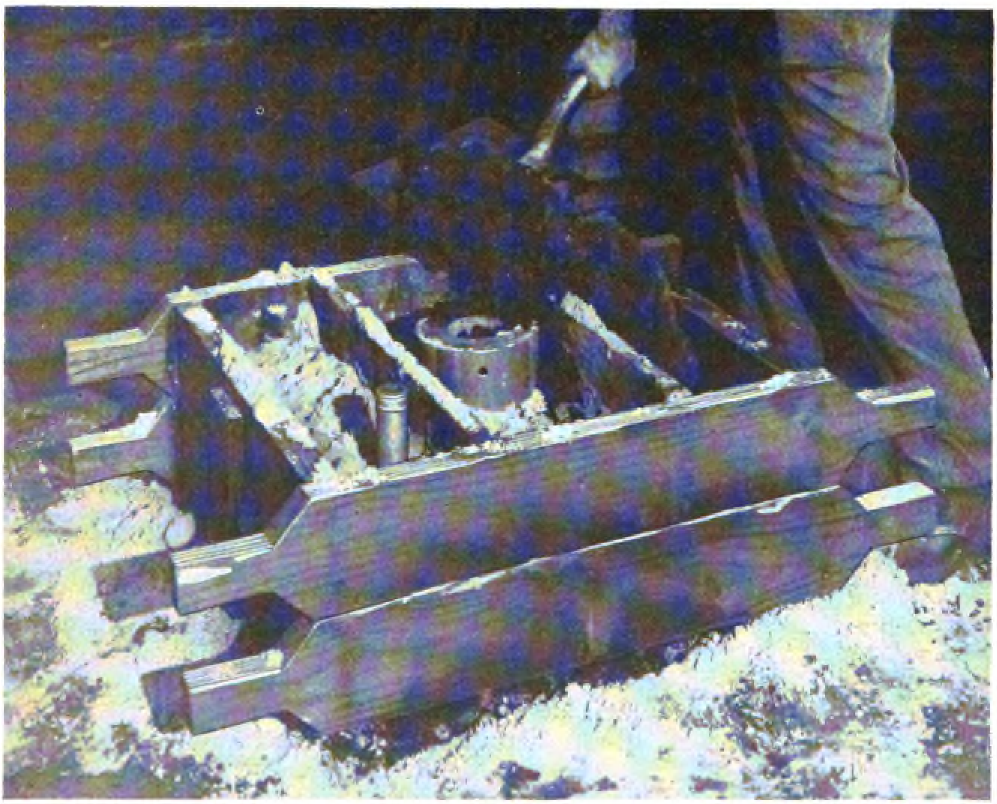

*Figure 22. Adding backing sand to cope.*

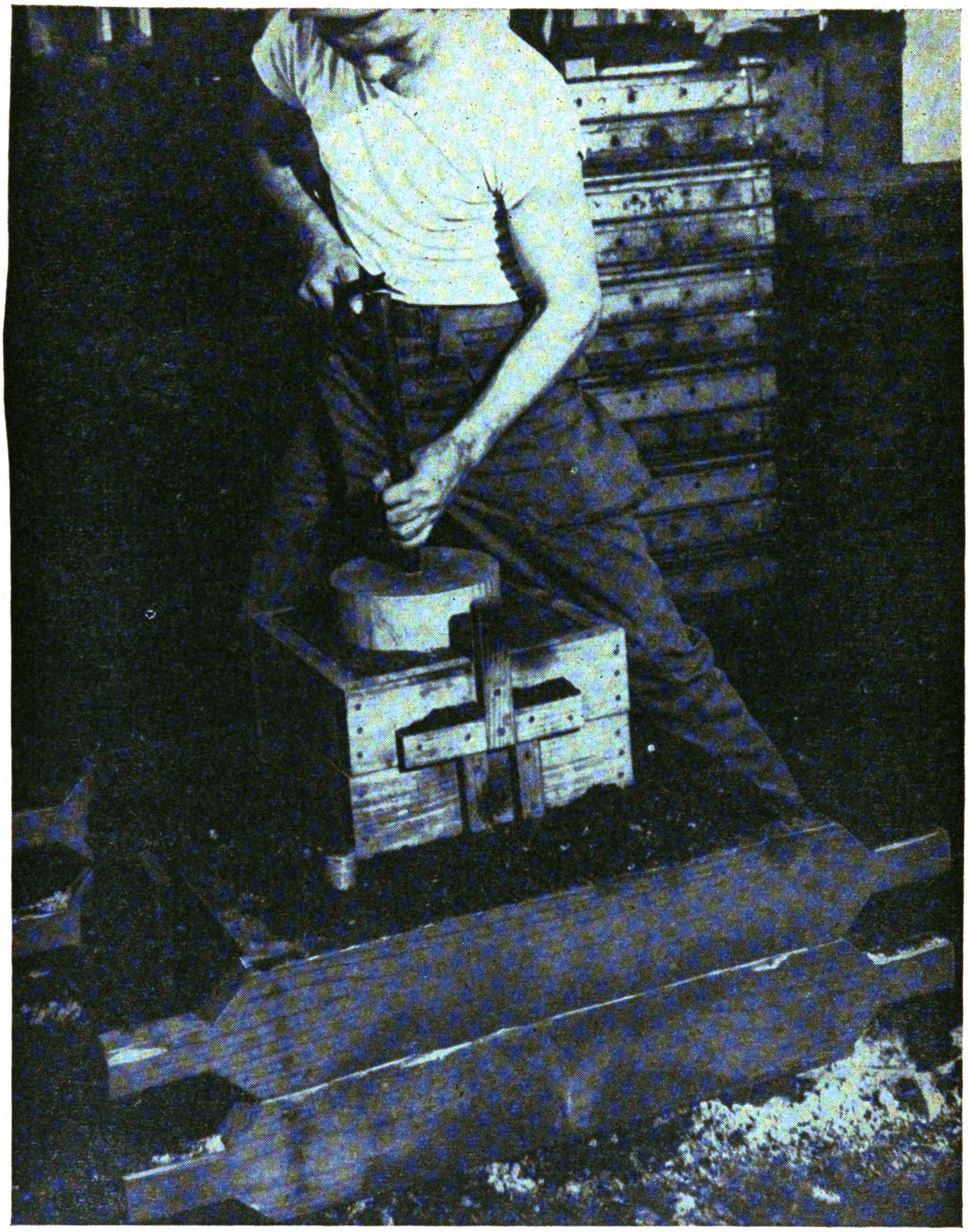

*Figure 23. Removing riser pattern from cope.*

(2) Cores are vented in the same manner as sand molds and then baked at about 450° F.; the time for baking depends on the size of the core. (See figs. 25 and 26.) After baking, they are usually medium to dark brown in color with a fairly hard surface. Frequently they are given a wash or rub with a material such as plumbago, to give a smooth surface. Silica washes are used to give greater heat resistance.

(3) Prints or chaplets hold a core in place in the mold. (See fig. 27.) A print is an indentation in the mold; a portion of the core fits in the indentation and holds the core in position. A chaplet is a piece of metal, used when

*Figure 24. Drawing pattern from drag. Note cope in background.*

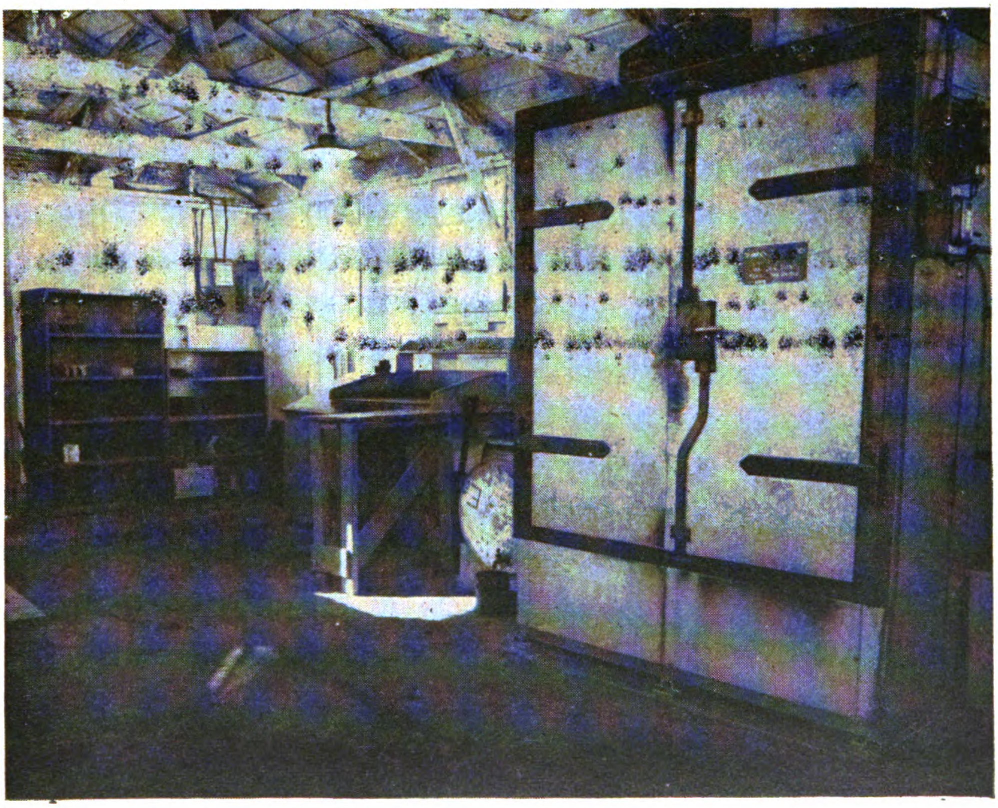

*Figure 25. Exterior view of oil-fired core oven.*

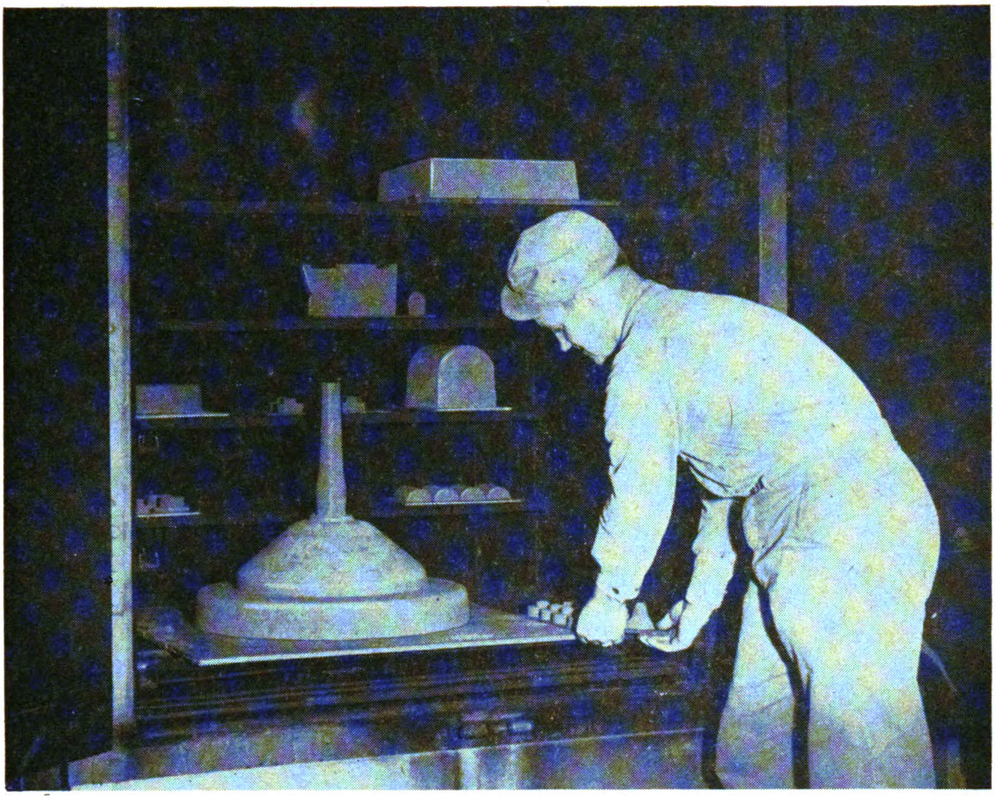

*Figure 26. Interior view of core oven.*

the core is not in direct contact with the mold. One end of the chaplet fits against the mold; the other end holds the core. When metal is poured into the mold, the chaplet fuzes with the metal and becomes part of the casting.

(4) Cores should be stored in a clean, dry atmosphere. After they have been in storage for any length of time, they should be baked in a core oven for about 20 minutes at 450° F. before being used.

**i. Closing mold.** After the cores are set, the cope is replaced on the drag. Jackets and weights or clamps hold the parts together. (See figs. 28 and 29.) The mold is now ready to receive the molten metal.

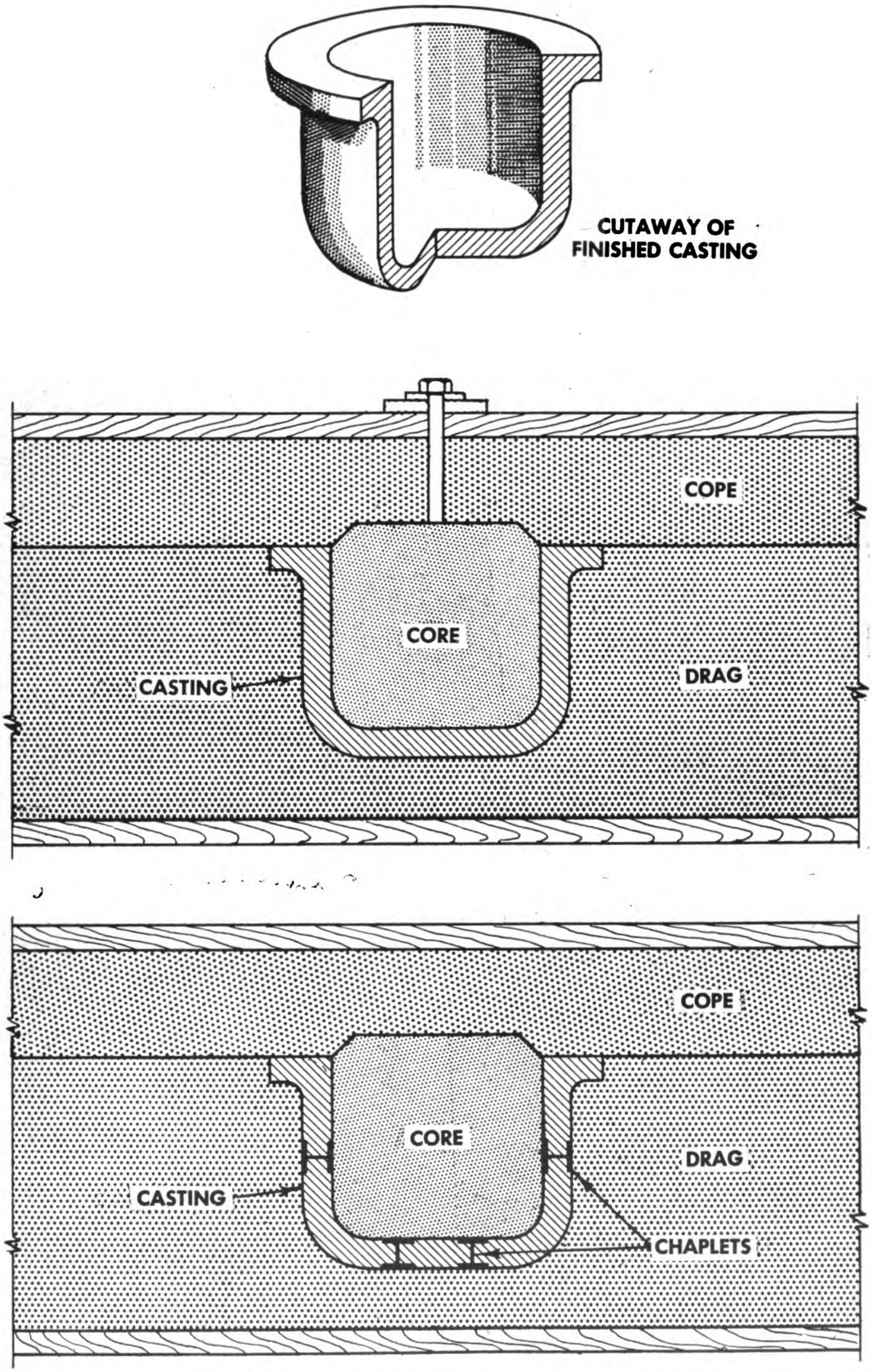


*Figure 27. Two methods for supporting a core.*

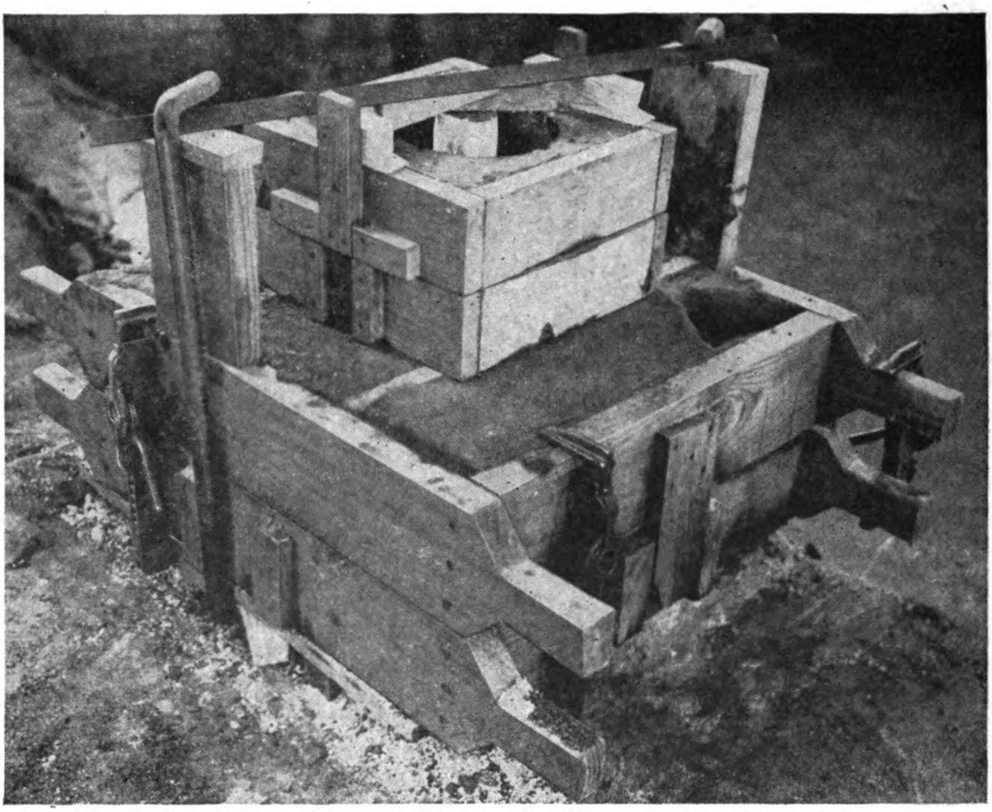

*Figure 28. Mold after closing, showing use of clamps.*

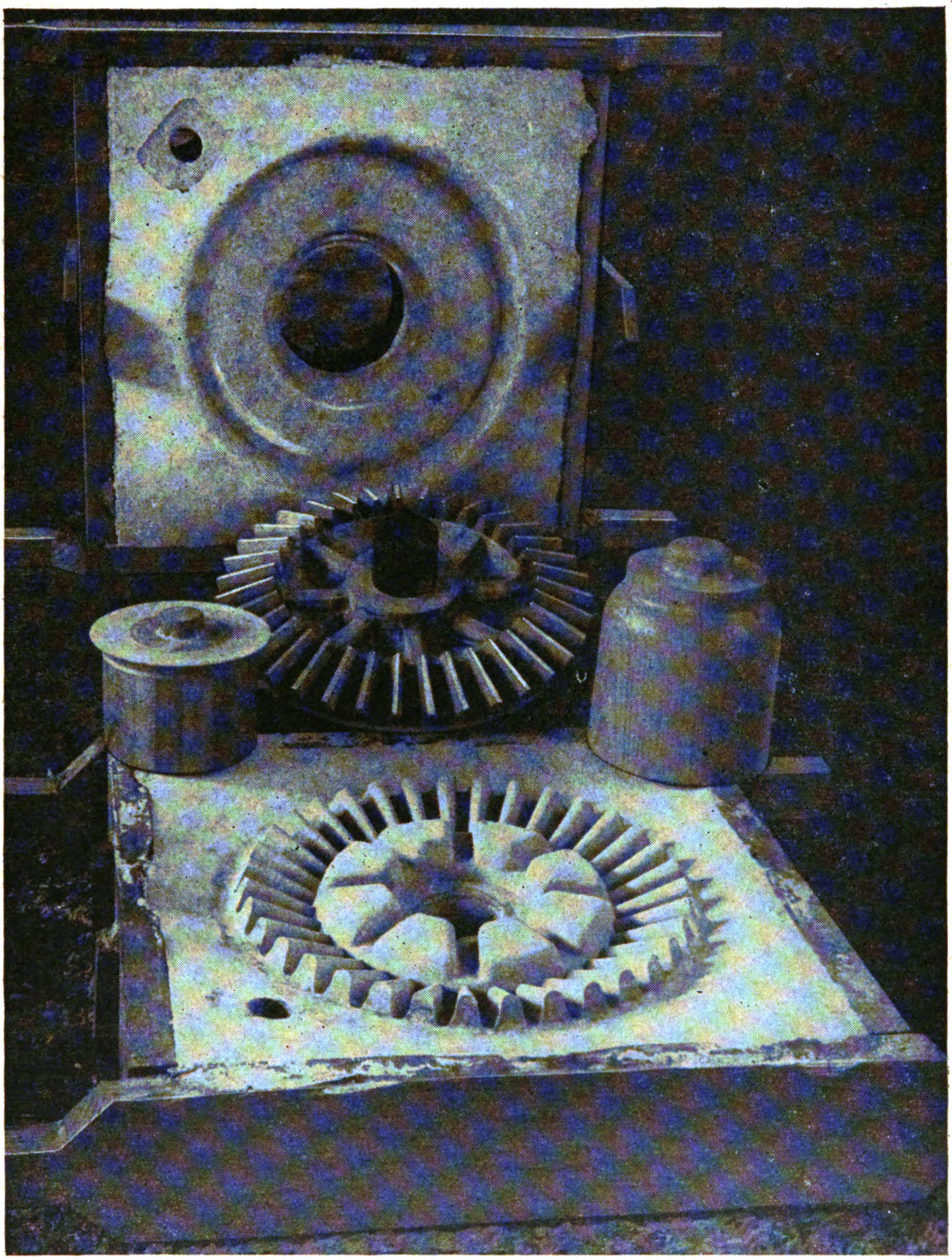

*Figure 29. Finished mold. Pattern and cope in background.*

## SECTION IV
# CASTING

**16. GENERAL.** The engineer foundry may make castings of cast iron, steel, aluminum, brass, or bronze. In general the melting procedure varies only slightly, depending on the properties of the different materials.

**a. Cast iron.** Cast iron (grey iron) is an alloy of iron and carbon, with small percentages of elements such as silicon, manganese, phosphorus, and sulfur. The alloy contains over 90 percent iron and from 1.8 to 3.5 percent carbon. Much of the carbon is in the form of microscopic flakes of graphite which impart a property known as self-lubrication. They also cause the grey color of a fractured surface.

**b. Steel.** Steel is also an alloy of iron and carbon, but with a lower carbon content than cast iron. In mild steel the carbon content is 15 to 25 points (0.15 to 0.25 percent); in medium-carbon steels it is 30 to 50 points; in high-carbon steel it may be over 100 points. Steel has a higher melting point than cast iron and is therefore harder on crucibles and on molding sand.

**c. Aluminum.** Aluminum is a silver-colored lightweight metal. Its melting point is lower than cast iron.

**d. Brass and bronze.** Brass is an alloy of copper and zinc; bronze is an alloy of copper and tin. Bronze is lighter colored than brass. The copper content of the alloy can be estimated from the color; the higher the copper content, the more reddish-yellow the color. Both brass and bronze have lower melting points than cast iron.

**17. INDUCTION MELTING UNIT.** An induction melting unit (fig. 30) is used to melt the metal for the casting. In the unit, a Diesel motor-driven electric generator (fig. 31) supplies power to an electric-motor high-frequency generator and to an amplidyne motor-generator set; the latter controls the field current in the high-frequency generator. (See fig. 32.) The high-frequency current passes through an induction coil cooled by water circulating inside it. (See fig. 33.) A crucible containing the metal to be melted is placed in the coil. (See figs. 34 and 35.) The metal acts as the secondary of a high-frequency transformer; the heat of the induced current melts the metal.

For a detailed discussion of operation of the melting unit, see the Ajax Electrothermic Corporation instruction manual.

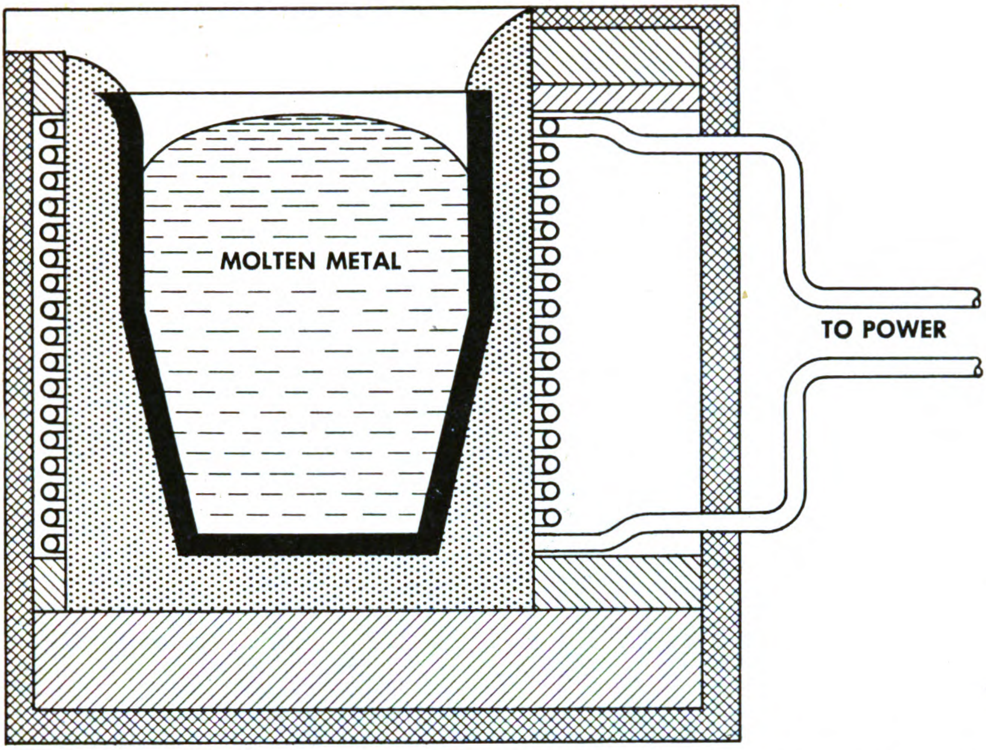


*Figure 30. Diagram illustrating operation of induction furnace. Copper tube carries high-frequency current and water to cool the coil. Charge in crucible is melted by induction.*

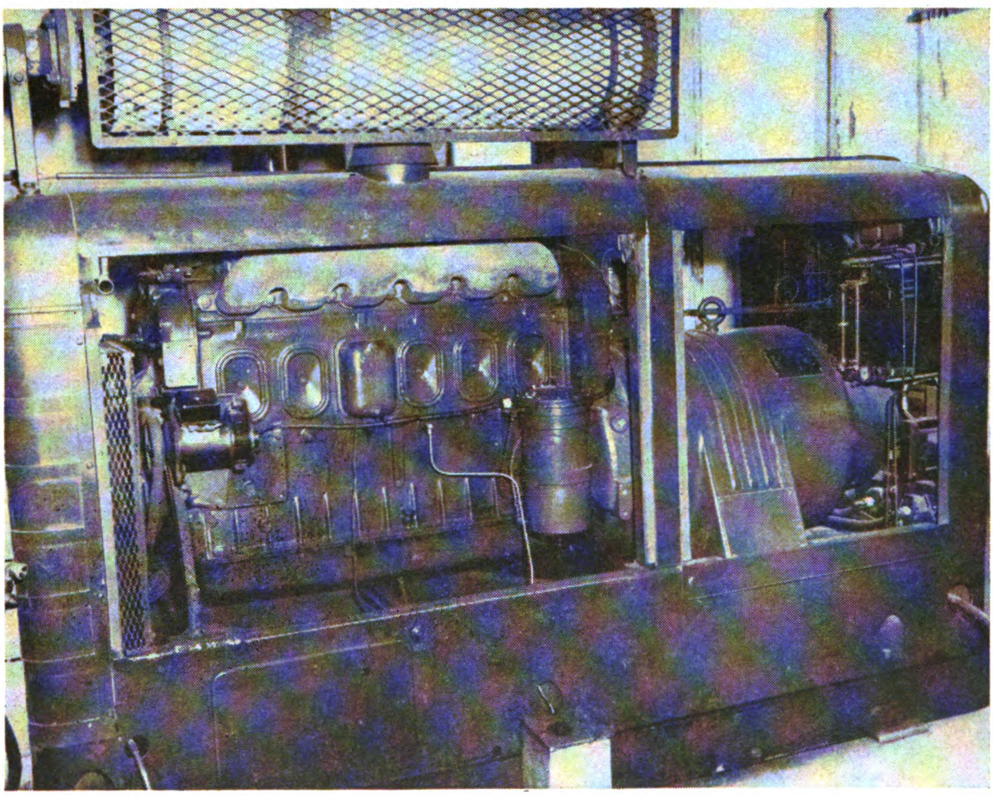

*Figure 31. 60-kw Diesel-motor generator.*

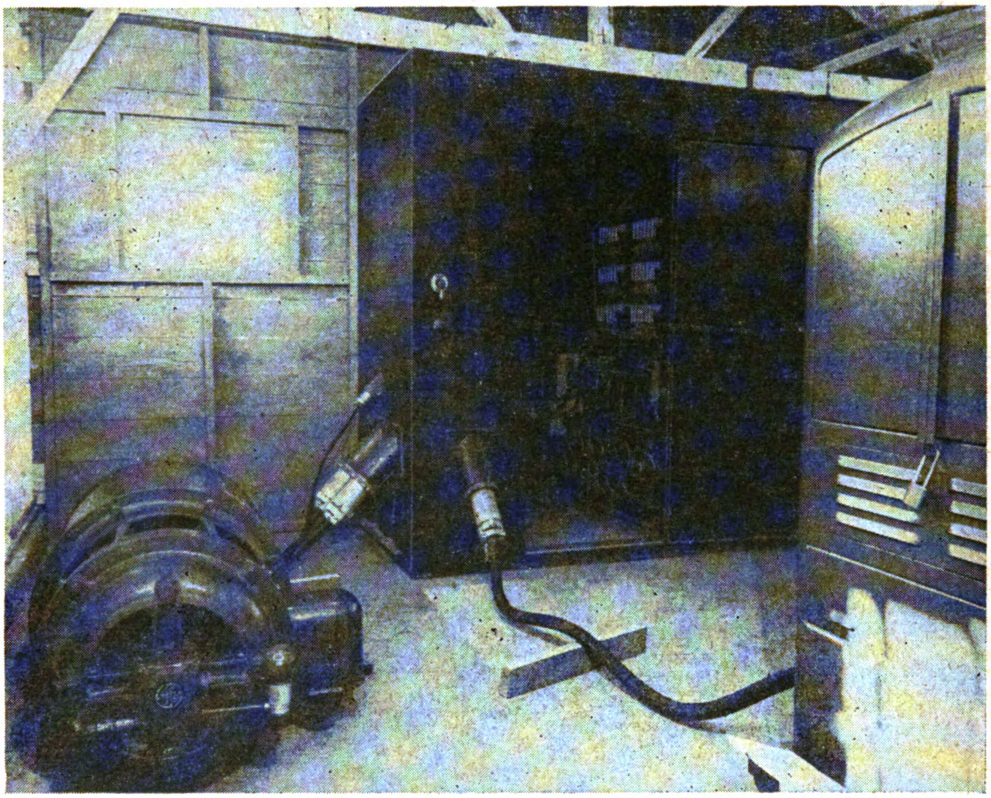

*Figure 32. Control cubicle with cables to Diesel generator and high-frequency motor generator.*

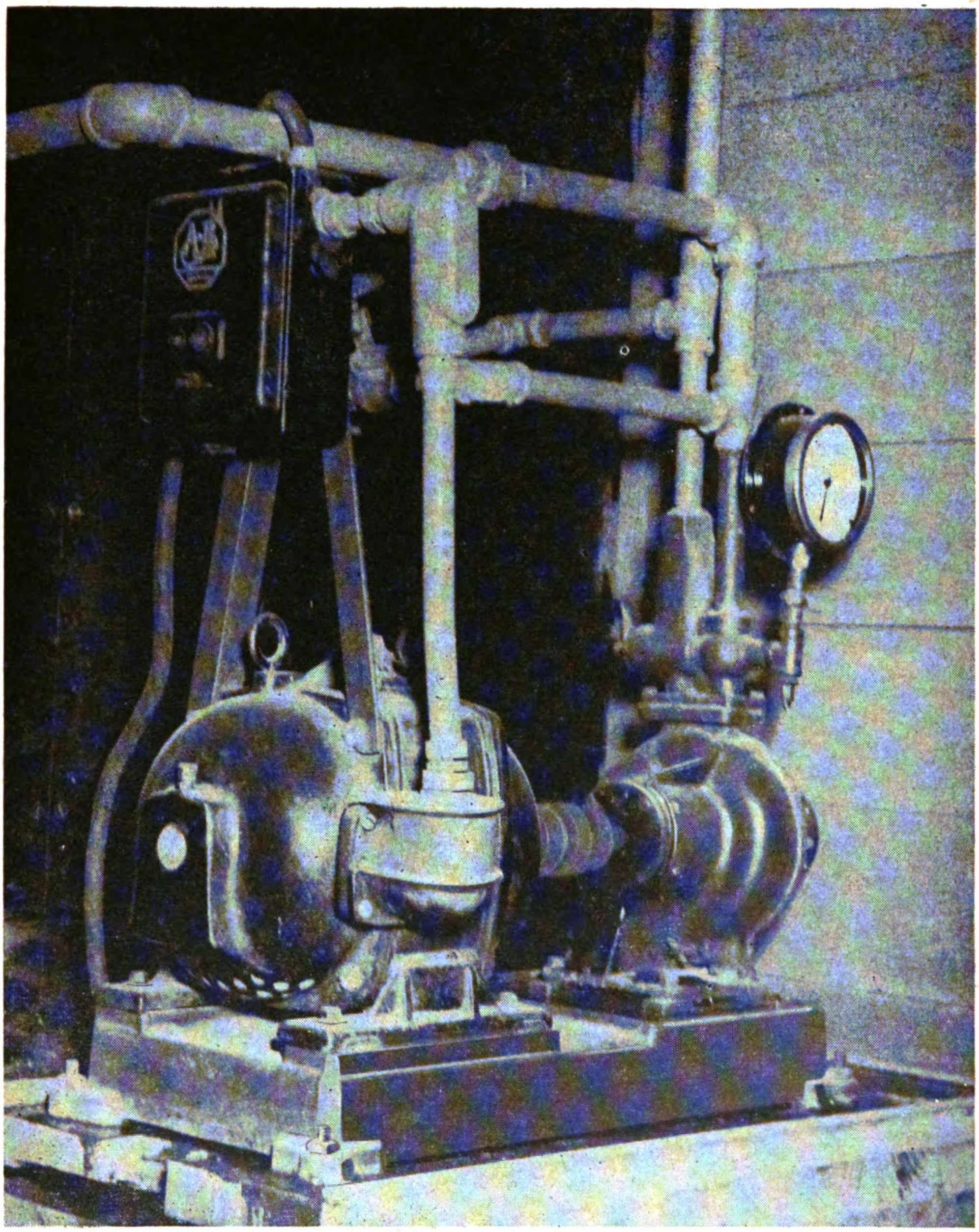

*Figure 33. Pump for circulating water through coil and capacitors.*

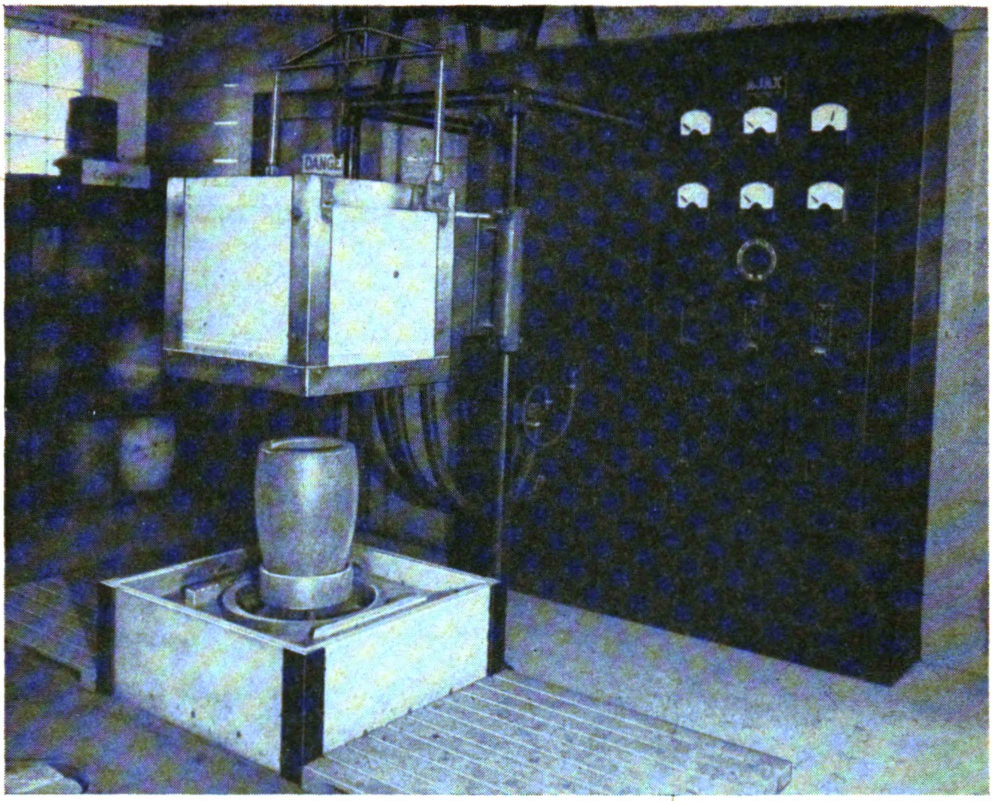

*Figure 34. Furnace with coil raised by chain hoist. Crucible in position.*

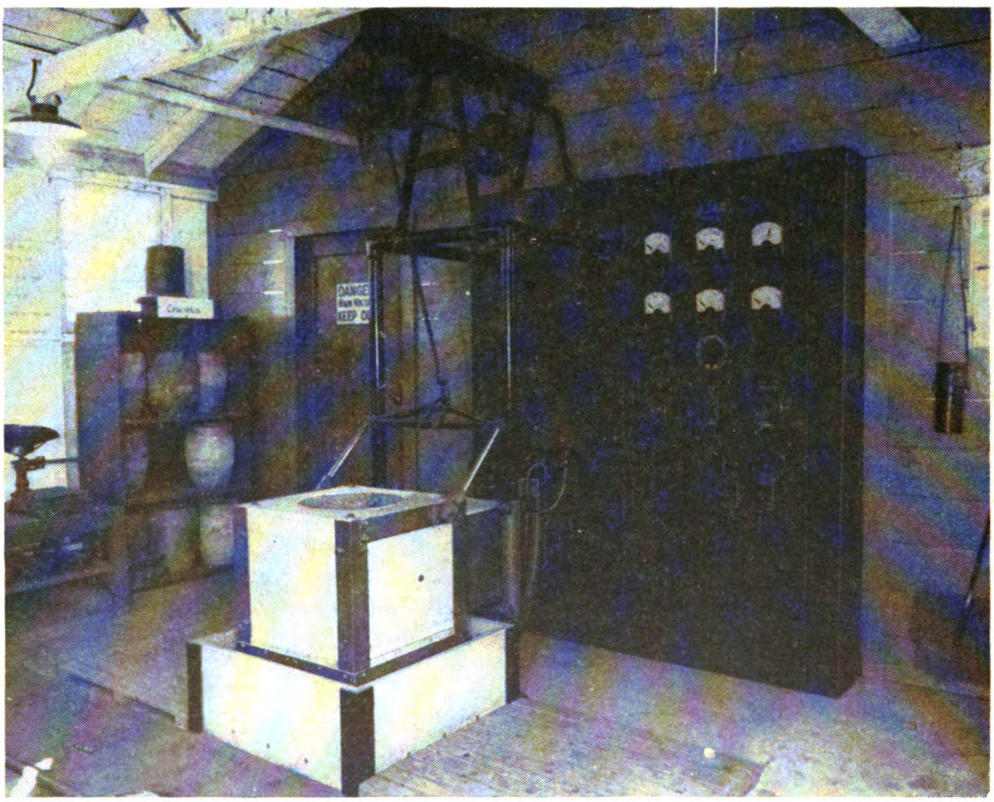

*Figure 35. Lift-coil induction melting furnace in "down" position.*

**18. CRUCIBLES.** Crucibles are used to hold the casting metal while it is being melted.

**a. Precautions.** (1) Crucibles should be tested before use by heating them for 24 hours at 250° to 300° F. The standard core oven is excellent for this purpose.

(2) Crucibles should be inspected while they are hot; cracks invisible in a cool crucible show up as light-colored lines on a hot crucible.

(3) Crucibles must be dry when they are placed in the melting unit. Under the high temperature of induction melting, moisture in the crucible may crack it or cause an explosion.

(4) Before making a heat, the melter should make sure the shank fits the crucible properly.

(5) During melting a spare crucible should be ready to receive the charge in case a break-out occurs.

(6) Graphite crucibles are brittle and must be handled with care; they must not be dropped, scraped, or gouged.

(7) When not in use, crucibles should be stored in a dry place at a temperature of 150° to 250° F.

**b. Charging the crucible.** (1) Charges of small pieces of metal are used so that maximum amount of metal can be placed in the cold crucible. (See fig. 36.) Boiler punchings or small 2- by 2-inch squares make an ideal charge.


*Figure 36. Adding charge of small pieces of scrap through hopper to crucible.*

The crucible should be filled to the top in such a manner that larger pieces can drop easily as they melt. Larger pieces should not be left near the top where they may form a bridge as melting progresses.

(2) The crucible is placed in the induction melting unit and the unit started as shown in the furnace manual. A pool of molten metal accumulates in the bottom of the crucible. (See fig. 37.) More metal is added until the desired quantity of molten metal is obtained. During the melting, skimmers are used frequently to remove any slag which has formed.

(3) The temperature of the molten metal is determined with a lance-type (immersion) pyrometer; for iron and steel, an optical pyrometer is used. (See fig. 38.)

**19. POURING. a. Precautions.** When the molten metal (heat) is ready, make sure *the floor between furnace and mold is clear of obstacles over which men carrying the heat might trip.* Make certain also that ingot (pig) molds are handy so the heat can be deposited in them if trouble develops in pouring. They are also used to receive the heel, the heat left over from the casting. (See fig. 39.)

**b. Operations.** The coil of the heating unit is raised; the crucible is picked up with a half shank, placed on the floor, and transferred to a full shank. (See fig. 40.) It is then carried to the mold and poured, usually by

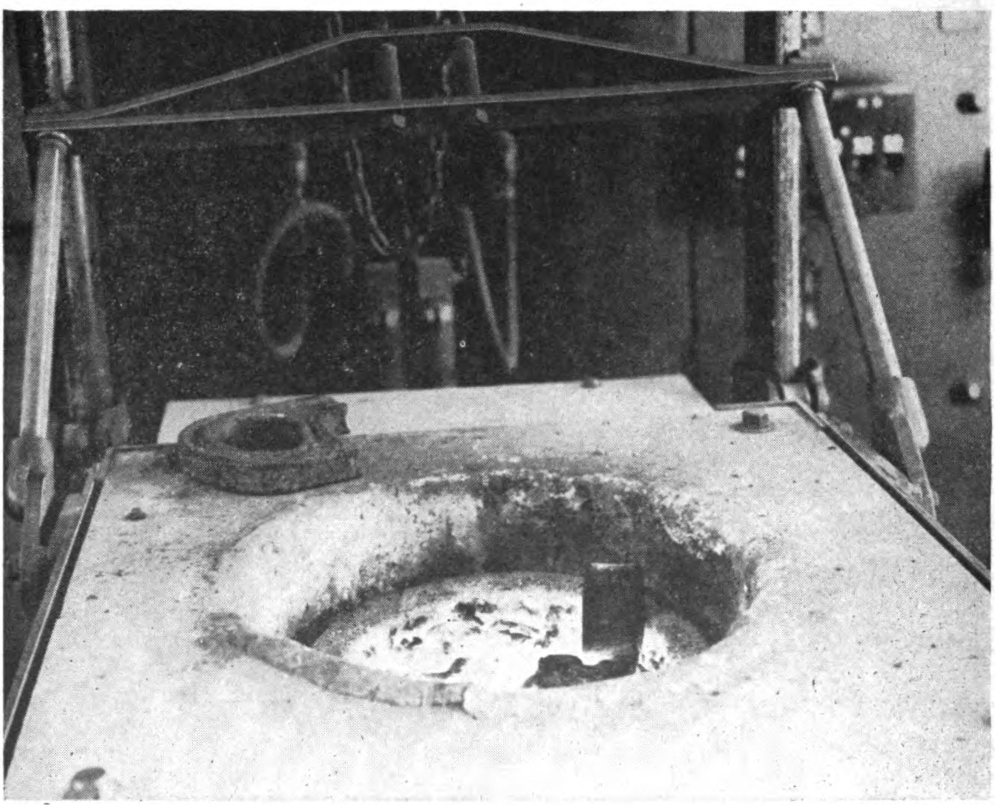

*Figure 37. Partly melted charge.*

*Figure 38. Using optical pyrometer to check temperature of metal before pouring.*

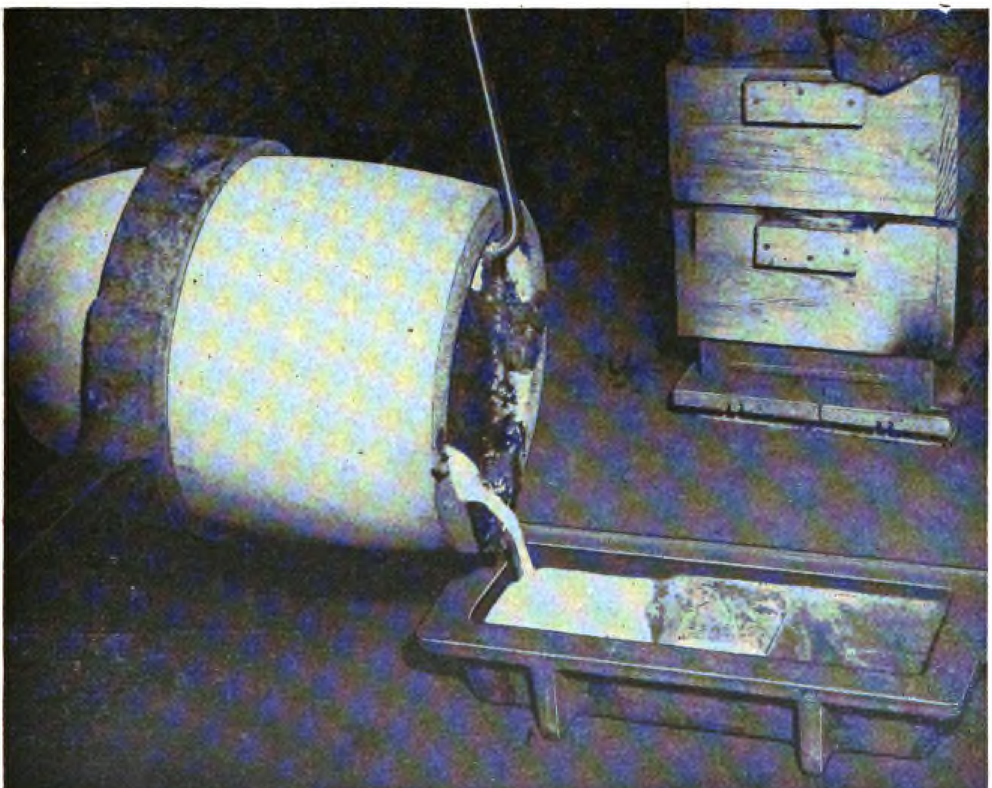

*Figure 39. Pouring heel into pig mold.*

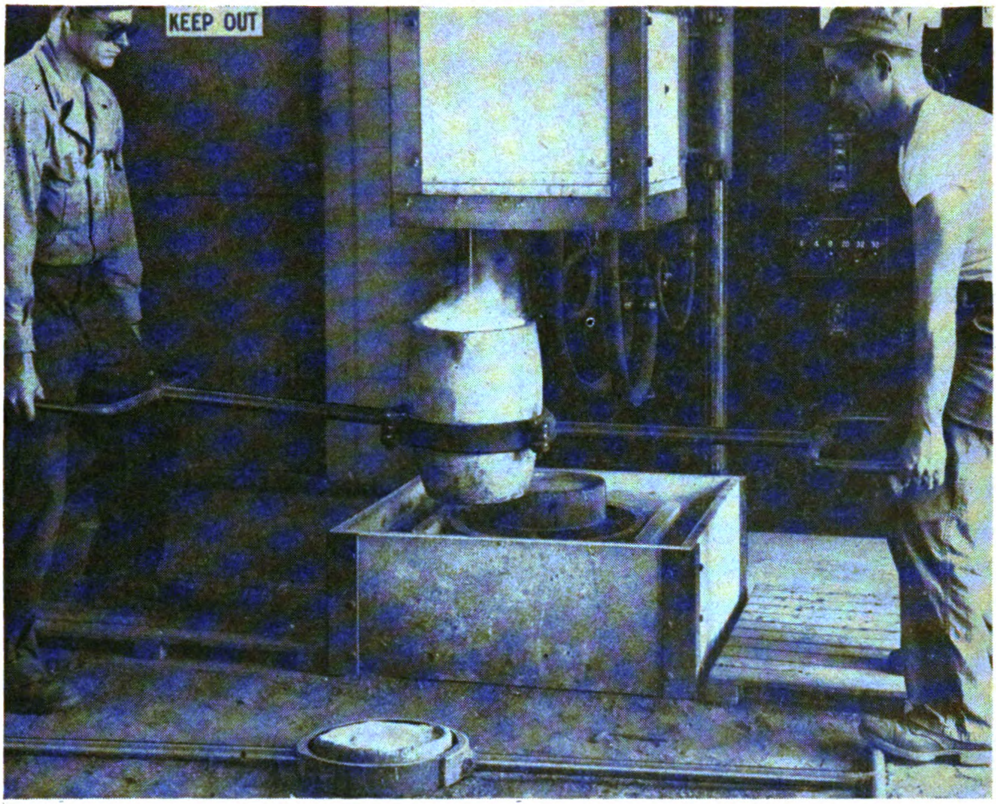


*Figure 40. Gated half shank used to transfer crucible to full shank on floor.*

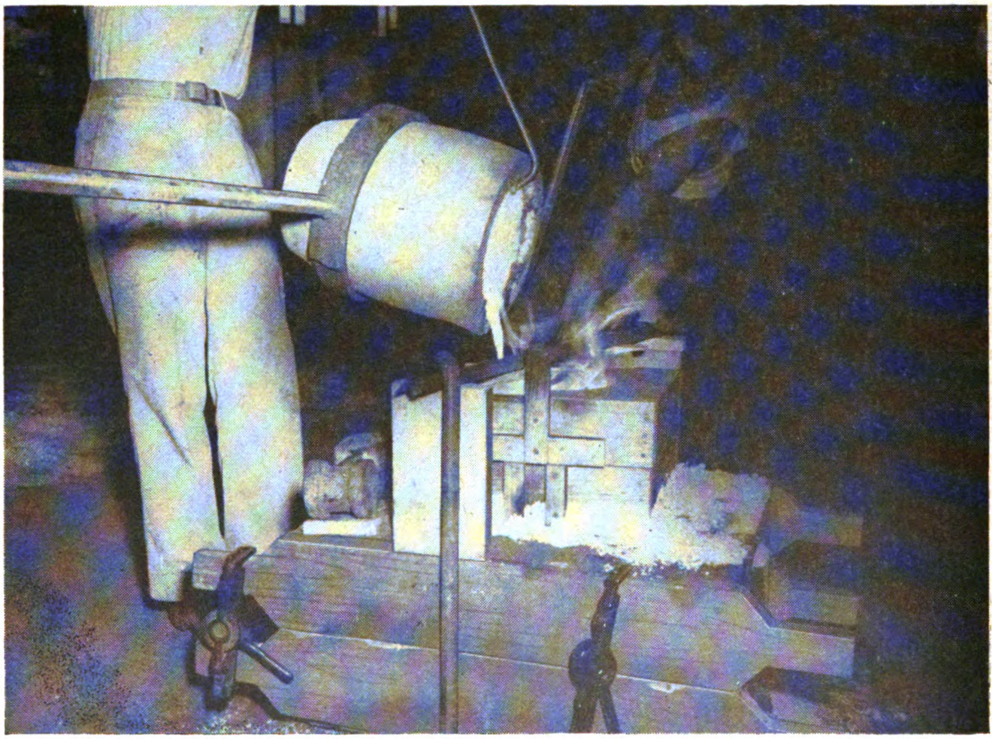

*Figure 41. Pouring the heat. Note use of holdback and skimmer.*

the molder or under his supervision. (See fig. 41.) The height at which the crucible is held and the size of the stream of metal poured depend on the size of the casting and the pouring pressure desired. Care must be taken to pour at the correct speed: pouring too fast may wash out portions of the mold; pouring too slow may result in light portions of the casting freezing and blocking metal from a part of the mold. Since slag causes defects in the casting, as little as possible is permitted to enter the mold; skimmers are used frequently to remove slag. (See fig. 42.)

**20. FINISHING. a. Shaking out** (fig. 43). A casting takes from 5 minutes to 3 hours to solidify, depending on its thickness and the type of metal used. Solidification can be observed from the condition of the gates and risers; when they become solid and give off a metallic ring when struck by a hammer, the casting can be removed from the mold (shaken out). Unless the casting is shaken out as soon as possible, it dries out the sand. It is important when removing the casting to avoid contaminating the sand with pieces of metal or scale; core sand should not be permitted to mix with backing sand.

**b. Cleaning.** (1) After the casting has been shaken out, gates, sprues, and risers are removed. On cast-iron castings they are brittle and can easily be broken off. On steel castings they are usually too large and must be cut

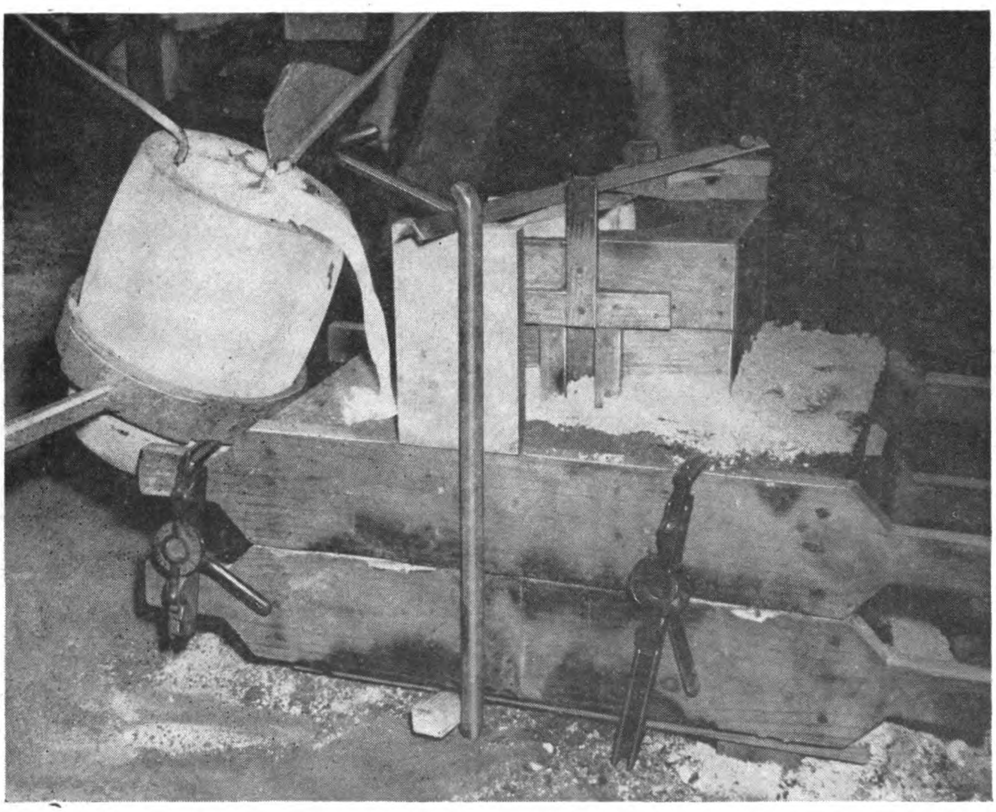

*Figure 42. Pouring remainder of heat into riser. Pouring gate was closed off when mold was filled to that point.*

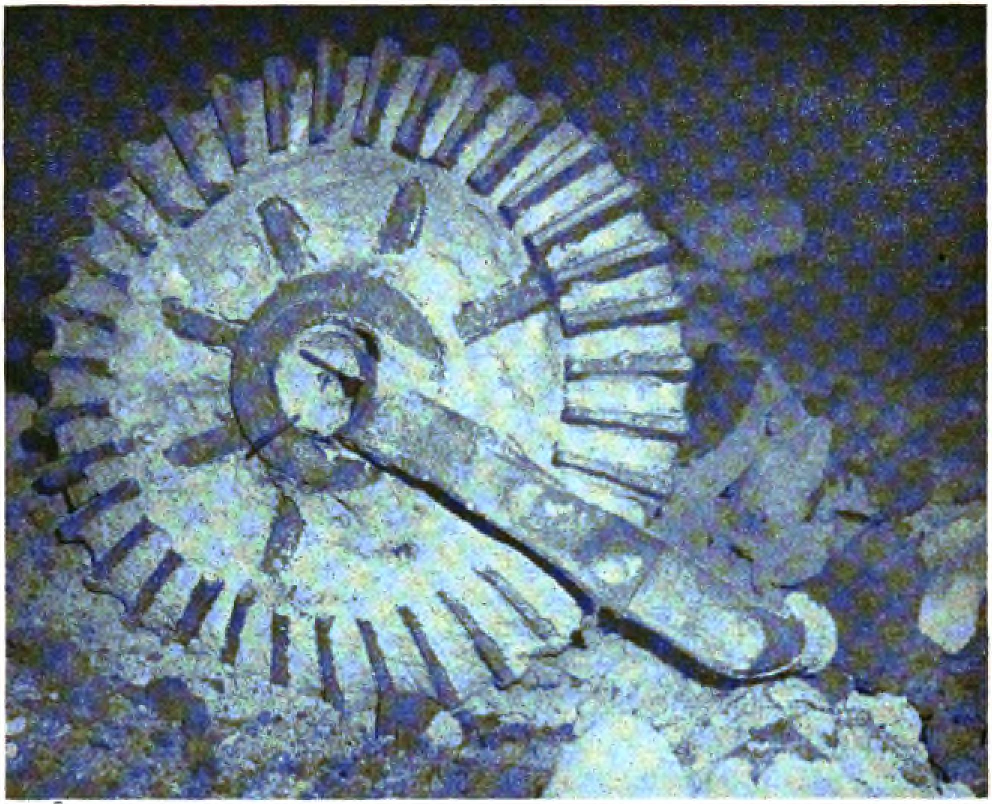

*Figure 43. Pinion gear as it was shaken out of mold. Note sand to be cleaned off.*

*Figure 44. Cutting off gate with oxyacetylene torch.*

or burned off. They must also be cut or burned off nonferrous castings because the metal is too ductile to be broken off. (See fig. 44.)

(2) Particles of molding sand, scale, and fins are then removed from the casting by tumbling, sandblasting, or shotblasting. Removal of sand particles is particularly important if the casting is to be machined; if left they would quickly ruin the cutting edge of machine tools. Fins are formed in the casting where the metal has run into spaces between parts of the mold.

(*a*) A tumbling mill is a rotating cylinder into which castings, sharp-edged pieces of cast iron (jack stars), and pieces of wood are placed. As the mill revolves, the jack stars and the wood strike and rub against the castings, smoothing the rough edges and knocking off sand and scale.

(*b*) In sandblasting and shotblasting, the casting is cleaned by a high-pressure stream of compressed air and sand or shot.

(3) The final step in cleaning the casting is grinding with an emery wheel and hand filing. At this point, the casting is inspected carefully for defects such as cracks, shrink holes, gas or sand holes, and slag inclusions. Defects should be studied to determine whether they are caused by molding. Some defects can be repaired by welding, others may mean rejection of the casting. If the casting is satisfactory (fig. 45) and no heat treatment is necessary, it is ready for machining. (See fig. 46.) Tests on sprues or risers for hardness and ductility show whether heat treatment is required.

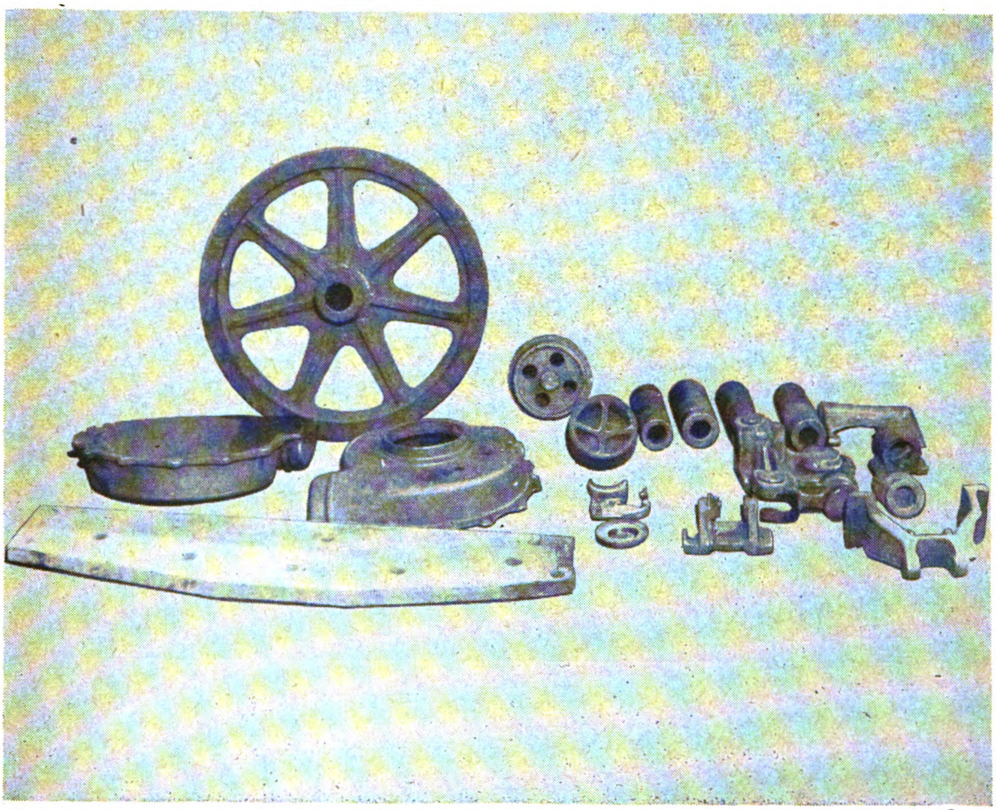

*Figure 45. Typical castings produced by an engineer foundry.*

**21. HEAT TREATING.** The engineer foundry is normally concerned with only two types of heat treatment: annealing and stress relieving. Quenching and tempering, to improve physical qualities, require special skills; they should be attempted only by qualified heat treaters.

**a. Annealing.** Castings too hard to machine are softened by annealing. The castings are heated to a light cherry-red (about 1,700° F.) and are then cooled slowly in the furnace. Cooling in air (normalizing) has a milder softening effect, but it usually improves the strength and ductility of the casting.

**b. Stress relieving.** Relieving stress has little effect on the physical properties of castings, but removes internal stresses which might cause the casting to fail later. It also makes castings easier to machine. Stress-relieving heat treatment differs from annealing only in that the casting is heated to a visible red (about 1,000° F.).

*Figure 46. Finished casting being machined.*

## SECTION V
# EXPEDIENTS

**22. GENERAL.** Foundry units in the field frequently may be without standard equipment required for a particular job. An ingenious foundryman will be able to improvise expedients to supplement those discussed in the following paragraphs.

**23. MOLDING SAND.** An expedient molding sand can be obtained from beaches and river bottoms. The clay content must be adjusted to obtain the qualities required of a foundry sand. Beach sands, for example, contain little or no clay and the desired amount of clay must be added; other sands may have to be washed to decrease their natural clay content.

**24. FLASKS.** Flasks can be improvised from scrap lumber built to the desired shape. (See fig. 12.)

**25. CORE OVEN.** A satisfactory oil-fire core oven can be made by placing a tank-car heater in a pit dug in the ground.

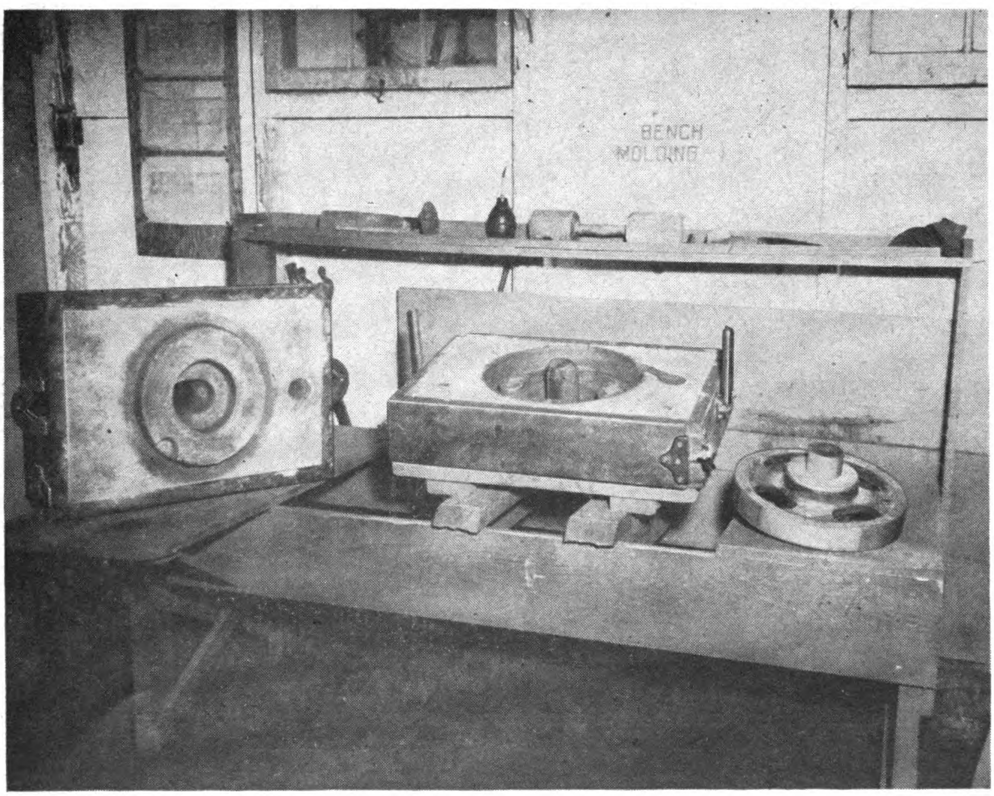


*Figure 47. Cope and drag of snap-flask mold using built-up casting as pattern.*

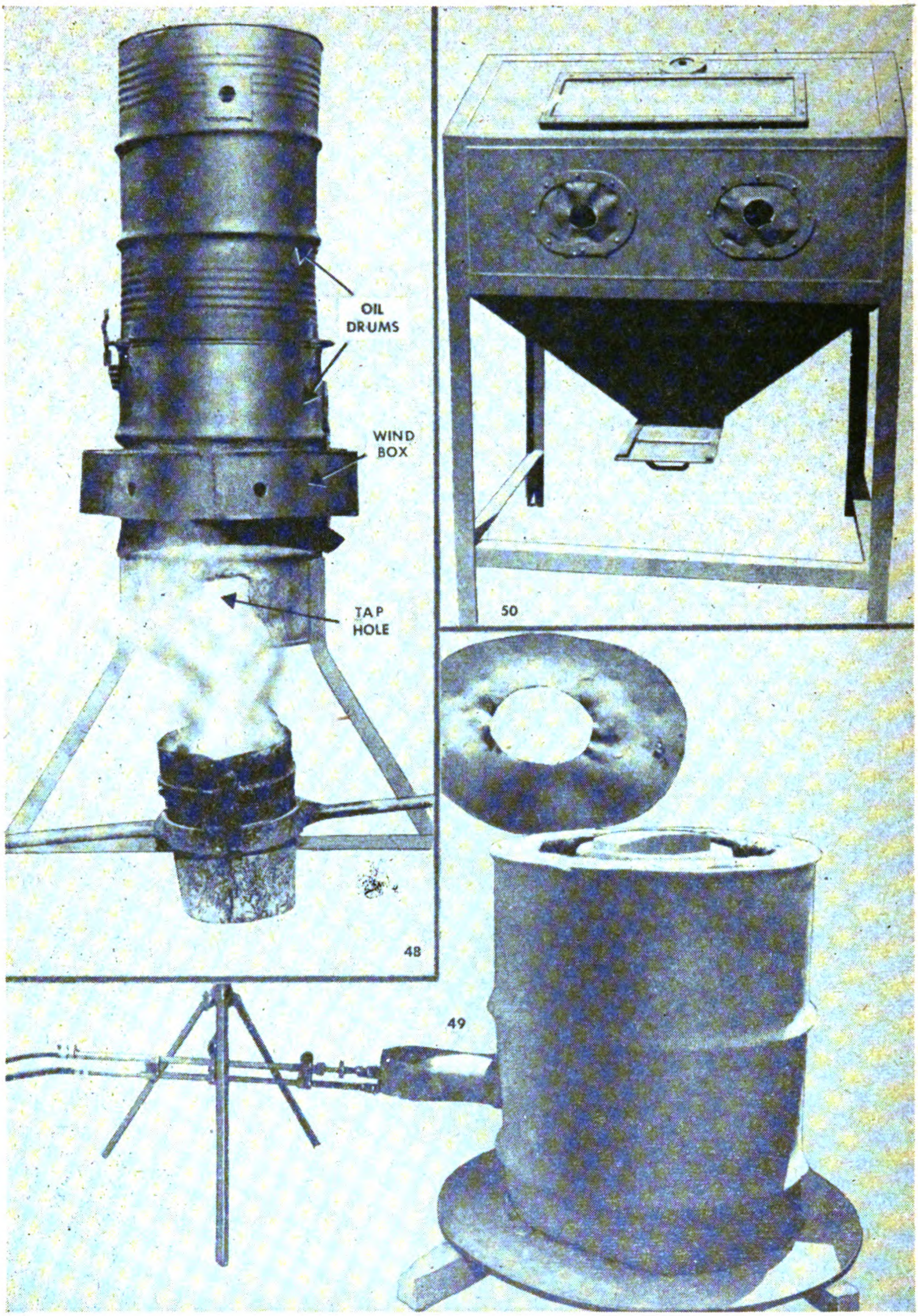


*Figure 48. Expedient cupola furnace for cast iron. Made of two brick-lined oil drums with windbox welded on.*

*Figure 49. Expedient crucible furnace for aluminum and bronze. Made of a brick-lined oil drum fired by a welder's preheater.*

*Figure 50. Expedient sandblast cabinet.*

**26. MELTING FURNACE. a. Crucible furnace.** A pit dug to provide a strong natural draft serves as a satisfactory crucible furnace. It is fired by coal, coke, or wood.

**b. Cupola furnace.** A cupola furnace can be made by welding together two oil drums. (See figs. 48 and 49.) The drums are lined with brick held in place by mud. An air blast is provided by a wind box connected to a motorized air compressor. About 300 pounds of cast iron per hour can be tapped from a furnace of this type. It can be operated for as long as 12 hours without relining.

**27. CLEANING EQUIPMENT. a. Sandblast cabinet** (fig. 50). A sandblast cabinet can be built of steel plates welded together. A metal spraying machine, standard equipment in the heavy shop company, is easily converted to use as a sandblast tank.

**b. Tumbling mill.** A tumbling mill can be improvised from oil drums. A salvaged automobile engine can be used to provide power for turning it.

# APPENDIX I
# DEFINITIONS

Special tools and terms are used by foundrymen. Every man in a foundry unit should be familiar with the "trade language." To help new men a list of terms has been prepared divided as follows:

1. Pattern making.
2. Molding.
3. Melting.
4. General.

## I. PATTERN MAKING.

*Air-dried lumber.* Lumber seasoned by being permitted to dry out naturally.

*Calipers, inside and outside.* Two bars or legs pinned at one end by a movable joint or spring and tapered at other end; points are bent out on inside calipers, in on outside calipers. Inside calipers measure internal dimensions; outside calipers measure external dimensions.

*Combination square.* Adjustable square used to form any desired angle.

*Depth gauge.* ¼-inch-wide steel scale marked in fractions of an inch, used to measure depths of holes in patterns.

*Dividers.* Similar to calipers, but have straight legs tapered to fine points. (Point may be attached to leg with adjustable joint for more accurate work.) Used to scribe circles and transfer measurements.

*Dowel pins.* Pins on joint between sections of parted patterns or core boxes to insure correct alignment.

*Draft.* Taper given the sides of a pattern so it can be easily withdrawn from mold.

*Draw nail.* Pointed iron or steel rod driven into wooden pattern for handle to withdraw it from mold.

*Draw peg.* Wooden peg used in same way as draw nail.

*Drawplate.* Metal plate set into pattern to facilitate withdrawing it from mold.

*Draw screw.* Rod with eye at one end and screw at other end screwed into pattern. Used in same way as draw nail.

*Fillets.* Concave corner pieces used to round off sharp corners; usually made of leather or wax.

*Gouge.* Metal hand tool with blade sharpened to 60° angle, used for shaping wooden patterns.

*Inside marking gauge.* Round steel scale with adjustable slide and a hard, carbon-steel point fastened securely at one end at a 90° angle to slide.

*Jointer.* Planing tool; consists of motor-driven, horizontal shaft with roller head for detachable cutting blades. Used for producing plane surfaces on wood.

*Lagging.* Building up pattern to larger dimension.

*Laminated construction.* Pattern member built up in a series of strips or segments, with alternate end joints midway between those in preceding course.

*Lathe (wood).* Wood-turning machine; consists of motor-driven head stock and adjustable tail stock on horizontal bed, mounted on cast-iron frame or table.

*Layout board.* Board on which pattern layout is made.

*Marking gauge.* Same as inside marking gauge; used only for gauging a line a fixed distance from the working edge.

*Match plate.* Wood or metal plate attached to pattern at the parting line.

*Miter box.* Small frame for holding stock and sawing accurately at a desired angle. Has protractor scale and guide to hold backsaw vertical.

*Miter and try square.* Square with either fixed or detachable handle, used for producing 90° or 45° angles.

*Nail set.* Metal punch used to recess nail heads in wooden patterns.

*Parting.* The plane along which pattern is split.

*Pattern.* Model of wood, metal, or other material for making metal reproductions in the same shape.

- *One-piece pattern.* Solid pattern; not necessarily made from one piece of wood.
- *Parted pattern.* Pattern made in two or more parts; also called split pattern.
- *Pattern layout.* Full-sized drawing of a pattern showing its arrangement and structural features.
- *Pattern lumber.* Close-grained wood capable of resisting splitting and hard enough to withstand normal usage and handling during molding.
- *Split pattern.* See *parted pattern.*

*Planes:*

- *Fore plane.* 18-inch-long plane with 2⅜-inch-wide plane iron.
- *Jack plane.* 14- to 16-inch-long plane with 2- or 2¼-inch-wide plane iron.
- *Jointer plane.* 22- to 24-inch-long plane with 2⅜- to 2⅝-inch-wide plane iron.
- *Smooth plane.* 5½- to 10-inch-long plane with 1¼- to 2-inch-wide plane iron.

*Plastic wood.* Air-drying wood-like substance used to patch holes in wood.

*Protractor.* Semicircular device marked in fractions of degrees.

*Sander (disk).* Sandpaper glued to motor-driven steel disk.

*Saws:*

*Backsaw.* Saw with steel rib along back of blade to stiffen it and make cutting more accurate. Blade is rectangular, 8 to 24 inches long.

*Band saw.* Saw with endless steel blade running over two large vertical pulleys with a table and attachments between the pulleys to support and guide material being cut. Lower pulley is fixed and power driven; upper pulley is adjustable. Blade is ¼ to 1 inch wide with 14 points per inch.

*Coping saw.* Narrow saw blade held in U-shaped frame. Blade is 6 to 8 inches long with fine ripsaw-shaped teeth. Used for cutting small arcs and circles.

*Crosscut saw.* Saw with 20- to 28-inch blade, 8 to 14 points per inch, tapered from handle. Teeth are fine, sharpened to needle point, with front edge tipped back about 8° from right angle with edge of blade. Used primarily for cutting across grain; may be used for cutting with grain.

*Ripsaw.* Similar to crosscut saw, but teeth are coarser, chisel shaped, with front edge at 90° angle to edge of blade. Used to cut with the grain.

*Table saw.* Motor-driven shaft assembled on a cast-iron frame with vertical adjustments. Circular saw blade mounted on end of shaft or arbor can be raised or lowered through a slot in the table. Table is assembled to frame with adjustments to tilt it to a 45° angle to saw. Table has adjustable fence used as guide.

*Shellac.* Refined, dried secretions of the lac bug; when mixed with alcohol to desired consistency and applied to pattern, gives hard, durable, smooth surface.

*Shrinkage rule.* Rule with graduations enlarged to compensate for shrinkage when the casting cools.

*Sizing.* Primary coating of thin glue put on end grain of wood to seal pores.

*Steel square.* A square with legs at right angles. Legs are graduated in fractions of an inch up to 2 feet, and have various tables of measurement inscribed on them.

*T-bevel.* Handle and movable blade used for scribing any angle.

*Trammel points.* Two individual steel points attached to slides with setscrews, and adjustable on either a steel or wooden beam. Used for transferring measurements and drawing large circumferences and arcs.

## 2. MOLDING.

*Albany sand.* Sand found around Albany, New York; bond, or clay, is present naturally.

*Arbor.* Bar or mandrel used as the center on which a core is built up.

*Baked core.* Dry-sand core which has been heated, usually in an oven, to harden it and fix its shape; opposite of green core.

*Balanced core.* Core with core-seat portion shaped and dimensioned so it overbalances that part of core extending into the metal cavity.

*Bars.* Ribs placed across cope of flask.

*Battens.* Wooden bars or strips fastened to patterns to hold them straight or to prevent distortion while ramming mold.

*Bead slicker.* Tool for finishing hollow place in mold.

*Bedding a core.* Resting an irregularly shaped core on a sand bed for drying.

*Bedding in.* Sinking a pattern to the desired position in the sand and ramming the sand around it.

*Bellows.* Small bellows for blowing sand from joint and from deep pockets in mold.

*Bench.* Framework table at which small molds are made.

*Bench work.* Molds small enough to be made at molder's bench.

*Bentonite.* High-grade clay binder used in foundry sands.

*Blacking.* Thin facing of graphite or powdered charcoal brushed or dusted over surfaces of mold to protect sand from hot metal.

*Bottom board.* Rough board similar to pattern board on which finished mold rests.

*Butt.* Large round end of rammer.

*Chaplets.* Pieces of metal with various shapes used to support a core in a mold.

*Cheek.* Section or sections of flask between cope and drag.

*Combination core box.* Core box that may be altered to form a different shape core.

*Cope.* Top section of flask or mold.

*Core.* Sand, either green or dry, placed in mold to form cavity in casting.

*Core paste.* Paste made of a mixture of various flours and binders and used to paste core sections together.

*Core plate.* Metal plate used to support cores while they are being baked.

*Core print.* Part of pattern which has been designed to form seat to locate and support core within mold.

*Core oven.* Oven designed for baking or drying cores.

*Core rack.* Rack or shelf on which cores are stored preparatory to using.

*Corner tool.* Molding tool used for slicking and smoothing corners of mold.

*Cover core.* Core set in place during ramming of mold to cover and complete cavity partly formed by withdrawal of loose part of pattern.

*Crossbar.* Wood or metal bar placed in a cope to give greater anchorage to the sand than is afforded by its four walls.

*Cutting over.* Turning over sand to obtain uniform mixture.

*Double-ender.* Molding tool; combined slicker and spoon slicker.

*Drag.* Bottom section of flask or mold.

*Drawing the pattern.* Lifting pattern from completed mold.

*Dry sand.* Sand baked in oven after having been formed into mold.

*Dry-sand mold.* Mold baked in oven to fix its shape permanently and harden its surface.

*Flange tool.* Tool for finishing edges of flanges in mold.

*Flask.* Framework of wood or metal in which sand is packed to mold it around pattern.

*Flask pin.* Pins on joint of one section of flask; fit into sockets on other section to permit their separation and alignment.

*Flat-back.* Pattern with flat surface at joint of mold. A flat-back pattern lies wholly within the drag; joint of the cope is a plane surface.

*Flow-off.* Channel cut to permit metal to flow away from riser when it has risen in riser to a predetermined height.

*Gagger.* L-shaped rod to reinforce and help support sand in the cope.

*Gate.* Hole in cope through which metal is poured into mold.

*Gate-cutter.* U-shaped piece of metal used to form gate.

*Gate sticks.* Stick sets in cope while it is being rammed to form gate.

*Green core.* Core which has not been baked.

*Horn gate.* Semicircular gate to convey metal over or under certain parts of casting, so that it enters mold at or near center. Also used as skim gate.

*Joint.* Portion of mold where the upper surface of drag and lower surface of cope come together.

*Lifter.* Molder's tool with flat end at right angles to stem, used to lift loose sand from deep pockets in mold.

*Linseed oil.* Oil used as binding agent for cores. When baked in oven it causes sand grains to adhere together in strong, hard bond.

*Loose piece.* Part of pattern so attached that it remains in mold and is taken out after body of pattern is removed.

*Mallets.* Wooden or rawhide hammers used for rapping core boxes or patterns.

*Molasses.* Cane syrup used in bonding sands.

*Mold.* Sand impression of pattern; when filled with molten metal, produces casting of desired shape.

*Mold cavity.* Impression left in sand by pattern.

*Nails (chill).* Nails of various sizes and shapes suitable for inserting into mold cavity to produce rapid cooling of certain sections of casting.

*Ottawa sand.* Sand found around Ottawa, Illinois; contains no clay or bond, but is well adjusted to a synthetic bonding agent.

*Parting sand.* Fine, sharp, dry sand dusted on joint of mold to prevent cope and drag adhering to each other.

*Partimold.* Powdered lycopodium; used like parting sand.

*Peen.* Flat-pointed end of rammer. Also: operation of ramming mold with peen end of rammer.

*Permeability.* Rate at which gases can pass through sand.

*Plumbago.* Graphite used in foundry as facing for molds to produce smooth surfaces on castings.

*Rammer.* Tool used by molder for packing sand in flask around pattern.

*Ramming.* Packing sand around pattern to make a mold.

*Rapping.* Jarring pattern to loosen it from sand preparatory to drawing.

*Rapping iron.* Iron bar used to strike draw nail to jar patter preparatory to drawing.

*Rapping plate.* Metal plate attached to pattern for insertion of rapping iron.

*Riddle.* Sieve for sifting sand on pattern.

*Riser.* Gate formed over high portion of mold to show when mold is filled with metal; also acts as feeder and supplies additional metal to casting as casting cools and contracts.

*Rolling over.* Reversing position of mold.

*Runner.* Deep channel formed in top of cope, connecting with gates, into which the molten metal is poured.

*Sandblast.* Method of removing adhering sand from casting by blasting compressed air and sand against surfaces of casting.

*Sea coal.* Finely-ground bituminous coal used to mix with foundry sand for producing smooth surfaces on iron castings.

*Shrinkhead.* A large riser.

*Skim core.* Core set in skim gate to act as skimmer.

*Skim gate.* Sprue arranged to skim impurities from surface of molten iron as it flows into mold and restrain them from entering mold.

*Skin-dried mold.* Green-sand mold whose surface has been baked to depth of an inch or more.

*Slicker.* Elongated, thin, flat steel tool for smoothing surface of mold.

*Slurry.* Mixture used to fill joints of cores.

*Snap flask.* Flask hinged at corners and separable at one corner so it may be opened and removed from around completed mold.

*Spoon slicker.* Tool with spoon-shaped end for finishing a mold.

*Sprue.* Channel leading from gate to mold cavity. Also: metal which solidifies in these channels after casting has cooled.

*Strike or strickle.* Flat bar of iron or wood used for striking or sweeping excess sand from top of mold.

*Swab.* Small bundle of bound hemp or bulb sponge used to dampen sand along edge of pattern before drawing pattern.

*Tempering sand.* Dampening and mixing sand to produce uniform distribution of moisture.

*Trowel.* Tool used in slicking, patching, and finishing mold.

*Vent.* Small hole in mold to permit escape of gas.

*Vent wire.* Wire for making vent.

*Wedges.* Tapered wooden pieces used to tighten clamps around mold.

*Whirl gate.* Gate or sprue arranged so metal enters mold at a tangent with a swirling motion.

## 3. MELTING.

*Ammeter.* Instrument showing amount of current (amperes) flowing through electrical circuit.

*Basin.* Portion of cupola below tuyeres in which molten metal collects.

*Bed charge.* The first coke charged into cupola.

*Bod.* Ball of clay for closing tap-hole of cupola.

*Break-out.* Rupture of mold permitting metal to flow out at joint; also called run-out.

*Breast.* Portion of lining of cupola immediately surrounding tap hole.

*Charge.* Weighed amount of metal prepared for melting in either cupola or electric induction furnace.

*Circuit breaker.* Safety control which breaks electrical circuit when it is overloaded.

*Coil.* Water-cooled copper tubing coiled in turns in whose center metallic charge and crucible is placed for melting.

*Condenser or capacitor.* System of parallel, noncontacting plates with control "back-flow" of current from the coil thereby controlling power factor, or efficiency, of frequency-changer set.

*Cubicle.* Large metal inclosure containing all controls for the induction furnace.

*Cupola.* Shaft furnace for melting iron; iron and fuel are added in alternate layers; combustion is promoted by air blown in at bottom of furnace.

*Crucibles.* Refractory pots in which metal is melted in either induction furnace or oil-fired furnace.

*Deoxidation.* Removal of oxygen from molten bath.

*Diesel generator.* Main power source of melting unit; consists of a Diesel motor and an electric generator on a common shaft.

*Electric induction melting unit.* Electric furnace designed so metallic charges are melted by their resistance to an induced electric current.

*Ferro-manganese.* Alloy of iron (14 percent), manganese (80 percent) and carbon (6 percent) added to steel heats low in manganese.

*Ferro-silicon.* Alloy of iron (50 percent) and silicon (50 percent) added to steel heats as deoxidizing agent.

*Flux.* Chemical agent used to remove impurities and gases from molten metal.

*Frequency-changer set.* Large motor-generator set which steps up frequency of main power source, the power from which is applied directly to the coil.

*Hold-back.* Metal hook used to hold and fix crucible to shank while pouring.

*Induced current.* Current caused to flow in a metal not in actual contact with any electrical conductor.

*Kilowatts.* Measure of power of electrical circuit.

*Lance pyrometer.* A shaft containing a thermocouple, which is immersed below the surface of the molten bath to obtain a temperature reading.

*Lead.* Copper wire or cable which conducts an electrical current.

*Motor-amplidyne set.* Small motor generator which supplies current for field of frequency-changer set.

*Norpatch.* Refractory material used to patch or line induction furnace coil.

*Optical pyrometer.* Instrument consisting of system of lenses to measure optically temperature of steel and iron.

*Oxidation.* Union of metal with oxygen to form oxide of that metal, such as rust, or iron oxide.

*Pig iron.* High-carbon cast iron used to increase carbon content of cast iron or other iron alloys.

*Power-factor meter.* Instrument showing the power factor, or efficiency, of the frequency-changer set.

*Pumping.* Feeding iron to casting from a shrinkhead by forcing it in with rod moved up and down in shrinkhead.

*Pressure switch.* Switch acting as circuit-breaker to open circuit whenever water pressure drops below a minimum value.

*Rheostat.* Variable resistance.

*Shank.* Device for carrying ladles or crucibles.

*Skimmer.* Metal bar or flat plate used to keep slag and dross away from lip of crucible while pouring castings.

*Slag.* Impurities fused with the flux in the melting furnace.

*Slag-hole.* Opening in cupola through which slag is withdrawn.

*Sodium silicate.* A mixing agent for Norpatch; commonly known as water glass.

*Tap switches.* Double-pole switches controlling number of turns in coil.

*Tongs.* Large, long-handled pliers or holders used for handling hot materials.

*Tuyeres.* Openings in cupola through which air is blown.

*Voltmeter.* Meter showing voltage of electrical circuit.

*Wind box.* Chamber surrounding cupola through which air is conducted to tuyeres.

## 4. GENERAL.

*Aluminum shot.* Aluminum in the form of shot or small globules, used in final deoxidation of steel heats.

*Auger bit.* Boring tool with two main parts, twist and shank. Shank has a square-shaped tank to fit securely into chuck of brace. Twist has two cutting points: spurs which determine size of hole and core the circle, and the lips which cut out wood within core.

*Auger bit gauges.* Stops clamped to auger bit and adjusted so only holes of certain depths can be bored.

*Automatic drill.* Consists of a chuck for holding the drill, mounted on a screw-shaped spindle which works back and forth into a ratchet assembled in the handle.

*Bench vise.* Consists of a central screw and parallel guide bars, one on each side of the screw and used to secure materials for working on a bench.

*Bit-brace extensions.* Steel rods of various lengths with square-shaped shank on one end and chuck on the other, used to extend length of brace.

*Boss.* Projection on casting of circular cross section.

*Brace (common and ratchet).* Tool for holding bit securely and for applying leverage to turn bit.

*Buckles.* Swellings on surface of mold due to generation of steam below the surface.

*C-clamp.* Malleable-iron frame shaped like letter *C* with a steel screw and swivel tip and handle; also called screw clamp and carriage clamp.

*Calipers.* Tool for measuring outside dimensions of cylindrical cores, etc., and for checking core placements in molds.

*Casting.* Product of foundry obtained by pouring molten metal into mold.

*Chamfer.* To bevel a sharp edge.

*Chill.* Iron surface (sometimes water-cooled) of mold, used to chill molten metal rapidly and thus produce hard surface on casting.

*Clamps.* Devices for fastening copes and drags together.

*Cold shut.* Imperfection in casting caused when metal enters mold by different sprues, and on cooling, fails to meet and unite.

*Countersink.* Cone-shaped bit for widening edges of holes drilled for flathead screws.

*Drill press.* Motor-driven adjustable vertical shaft with tapered spindle hole, mounted on cast-iron column on which a horizontal table is attached. Tapered spindle hole is used to attach chuck, which holds tool.

*Fin.* Thin projection or ridge occurring on casting at point where two sections of mold come together.

*Finish allowance.* Amount of stock left on surface of cast to be removed in finishing.

*Foundry.* Shop where castings are made.

*Forstner bit.* Bit with no twist or spurs. Has sharp circular steel rim for cutting and two lips within rim to clear wood from rim.

*Hand-screw clamp.* Two hardwood jaws with a steel spindle at the center and one at the back end. Jaws are opened or closed by holding a spindle in each hand and revolving the clamp.

*Refractory.* Having heat-resisting qualities.

*Scab.* Imperfection in casting caused when portion of mold surface breaks away.

*Scale.* Oxide crust on castings caused by exposure of hot surfaces to oxygen in air.

*Shot.* Globules of metal formed in body of casting and harder than rest of casting.

*Steel bar clamps.* Steel T-shaped beam or bar fitted with screw and crank at one end and steel head at the other. Head can be moved along bar and secured in position by means of slots in its lower edge.

*Tumbling mill.* Cylindrical cast-iron drum in which castings are cleaned by tumbling them with star jacks.

*Twist bit.* Similar to twist drill but with steeper cutting points; can only be used for drilling in wood.

*Twist drill.* Has two parts, shank and twist. Latter is tapered at end to 60° angle and sharpened to cut wood or metal.

*Warping.* Distortion of board through absorption or loss of moisture. As applied to casting, distortion because of uneven cooling.

*Wire brushes.* Brushes with wire bristles for cleaning castings.

## APPENDIX II

# TYPICAL ORGANIZATION FOR ENGINEER FOUNDRY UNITS

*(Based on T/O 5–500, C5)*

| Personnel | Number | Rank | SSN[1] |
|---|---|---|---|
| Foundry officer | 1 | First lieutenant | |
| Foundry foreman | 1 | T sgt | 088 |
| Core maker | 1 | Tec 4 | 129 |
| Furnace operator | 1 | Tec 4 | 129 |
| | 1 | Tec 5 | 129 |
| Molder | 1 | Tec 3 | 129 |
| | 2 | Tec 4 | 129 |
| | 1 | Tec 5 | 129 |
| Pattern maker | 1 | Tec 3 | 148 |
| | 1 | Tec 4 | 148 |
| Casting finisher | 2 | Pfc | 129 |
| Laborer | 1 | Pfc | 580 |
| | 2 | Pvt | 590 |
| Basic | 2 | Pvt | 521 |
| | 18 | | |

[1] See AR 615–26.

*Note*—This organization normally is assigned to a heavy shop company when required. It can produce the following quantities of molten metal per hour:

cast iron ........ 108 lb.
steel ........ 100 lb.
bronze ........ 132 lb.

On a 24-hour basis the following production can be expected:

cast iron ........ 2,000 lb.
steel ........ 1,600 lb.
bronze ........ 1,800 lb.

## APPENDIX III

# TYPICAL LIST OF FOUNDRY EQUIPMENT

*(Based on ASF Catalog ENG 6 820–01, Shop Equipment, Fifth Echelon – Set No. 1)*

---

### 1. PATTERN MAKING.

| *Nomenclature* | *Quantity* |
|---|---|
| ALCOHOL, methyl (wood alcohol) | 1 gal X |
| AWL, brad, 1/16 x 1 1/8 in | 1 ea |
| BEVEL, sliding T, wood handle, 6-in. blade | 1 ea |
| BIT, auger, hand, in set, 3/16- to 1-in., by sixteenths, set of 14 with box | 1 st |
| BIT, expansion, with 2 cutters, 7/8- to 1 3/4-in., 1 3/4- to 3-in. | 1 ea |
| BIT, Forstner type, hand, in set, 1/2-, 3/4- and 1-in | 1 st |
| BRACE, ratchet, 10-in. sweep | 1 ea |
| BRUSH, core painting, 2 1/2 in. wide | 2 ea |
| BRUSH, varnish, flat, double- x thickness, 1 1/2 in. wide | 1 ea |
| CALIPER, firm joint, outside, 10-in | 1 pr |
| CALIPER, spring, inside, 6-in | 1 pr |
| CALIPER, spring, outside, 6-in | 1 pr |
| CHISEL, woodworkers', paring, bent shank, bevel edge, in set, 1/4, 1/2, 1, and 1 1/2-in | 1 st |
| CHISEL, woodworkers', socket, firmer, handled, in set, 1/8, 1/4, 3/8, 1/2, 3/4, and 1-in | 1 st |
| COUNTERSINK, bit-stock shank, rose head for wood and soft metal, 1-in | 1 ea |
| DIVIDER, spring, 6-in | 1 pr |
| DIVIDER, wing, 10-in. | 1 pr |
| DRILL, hand, ratchet, 0 to 1/4-in | 1 ea |
| DRILL, twist, straight shank, fractional sizes, in set 1/16- to 1/2-in. by sixteenths | 1 st |
| FILLER, wood, paste | 10 lb X |
| FRAME, coping saw, with 1 doz. blades | 1 ea |
| GAUGE, carving, English spoon type, in set, 1/4-, 3/8-, 1/2-, and 5/8-in | 1 st |
| GAUGE, marking steel, scratch, 6-in | 1 ea |
| GAUGE, paring, straight shank, regular sweep, in set, 3/16-, 1/4-, 5/16-, 3/8-, 1/2-, and 5/8-in | 1 st |

| *Nomenclature* | *Quantity* |
|---|---|
| GLUE, casein type, water resistant | 10 lb X |
| HAMMER, carpenters', curved claw | 1 ea |
| KNIFE, drawing, folding handle, 8-in | 1 ea |
| LUMBER, hardwood, cherry, firsts and seconds dressed, 1 in. thick, random width and length | 500 bf X |
| LUMBER, softwood, SLYP or comparable grade, dimension, No. 1 common, dressed, 1 in. thick, random width and length | 2,000 bf X |
| OIL, linseed, raw | 25 gal X |
| PIGMENT, dry, lampblack | 3 lb X |
| PLANE, gauge, iron or steel, smooth bottom, 18-in | 1 ea |
| PLANE, router, iron or steel, 7½-in. steel, open throat | 1 ea |
| PLANE, smooth, iron or steel, 9-in | 1 ea |
| RULE, steel, spring tempered, shrink 1/10 in. per ft., 12 in. long | 1 ea |
| RULE, steel, spring tempered, shrink ⅛ in. per ft., 12 in. long.. | 1 ea |
| RULE, steel, spring tempered, shrink 5/32 in. per ft., 12 in. long. | 1 ea |
| RULE, steel, spring tempered, shrink, ¼ in. per ft., 12 in. long. | 1 ea |
| SAW, hand, back, 12-in., 14-point | 1 ea |
| SAW, hand, crosscut, 24-in., 10-point | 1 ea |
| SAW, hand, rip, type 24-in., 6-point | 1 ea |
| SCRAPER, cabinet, 2¾-in. blade, 11½-in. long | 1 ea |
| SHAVE, spoke, 2⅛-in. blade | 1 ea |
| SQUARE, carpenters', try, 8-in. blade | 1 ea |
| TRAMMEL, beam, with 20-in. beam and extension | 1 ea |
| VARNISH, shellac, orange | 5 gal X |

**2. MOLDING.**

| | |
|---|---|
| BAG, facing, fine, 9 x 17 in | 12 ea |
| BAG, parting, 5 x 9 in | 12 ea |
| BELLOW, molders', black, buck type, 10-in | 1 ea |
| BINDER, Bentonite, 200-lb. bag | 1,000 lb X |
| BOARD, bottom 16 x 18 in | 25 ea |
| BOARD, bottom 16 x 24 in | 25 ea |
| BRUSH, core box, 1⅛ x 5½ x 12 in | 2 ea |
| BRUSH, dust, camel hair (squirrel hair), 2 in. wide | 2 ea |
| BRUSH, dust camel hair (squirrel hair), 3 in. wide | 2 ea |
| BRUSH, dust, counter horse hair, 14 in. over-all | 1 ea |

| *Nomenclature* | *Quantity* |
|---|---|
| BRUSH, molders', hard or stiff bristle, 7 x 19 rows, 8½ in. long | 2 ea |
| BRUSH, molders, soft or dusting, 5 x 17 rows, 9½ in. long | 2 ea |
| CAN, blow or spray, molders', 1 pt | 1 ea |
| CAN, sprinkling, 3-gal | 1 ea |
| CLAMP, core box, 6-in | 2 ea |
| CLAMP, core box, 12-in | 2 ea |
| CLAMP, flask, 7- to 12-in | 4 ea |
| CLAMP, flask, 12- to 22-in | 4 ea |
| CUTTER, gate, ⅝ in. wide | 1 ea |
| CUTTER, tubular, spruce, No. 1, ½ x ⅞ x 6 in | 1 ea |
| CUTTER, tubular, spruce, No. 4, ⅞ x 1¼ x 6 in | 1 ea |
| FACING, seacoal, 200-lb. barrel | 200 lb X |
| FLASK, slip, taper, 14 x 16 in., 7-in. cope, 4-in. drag | 1 ea |
| FLASK, slip, taper, 14 x 22 in., 6-in. cope, 5-in. drag | 1 ea |
| FLOUR, silica, 200-lb. barrel | 200 lb |
| GLOVES, molders', asbestos | 2 pr |
| JACKETS, taper, 60-in., 8-in. depth | 6 ea |
| JACKETS, taper, 72-in., 8-in. depth | 6 ea |
| LEGGINS, molders', asbestos | 2 pr |
| MALLET, carpenters', round reinforced head, 2½ x 5½ in | 1 ea |
| MALLET, rawhide, 1½- x 3-in. head | 2 ea |
| OVEN, core, oil fired, 54 in. high, 36 in. wide, 24 in. deep | 1 ea |
| PARTING, perfect Non-sil, 200-lb. barrel | 1 lb X |
| PLATE, core flat, 8 x 12 in., with tongs | 12 ea |
| PLUMBAGO, 200-barrel | 200 lb X |
| RAMMER, bench, square shoulder, 2½ x 14 in | 2 ea |
| RAMMER, floor, hickory handle, 52 in | 2 ea |
| RIDDLES, 18-in. diameter, No. 4 | 2 ea |
| RIDDLES, 18-in. diameter, No. 6 | 2 ea |
| RIDDLES, 18-in. diameter, No. 8 | 2 ea |
| SAND, molding, Albany, No. 1½, 200-lb. bag | 20 bg X |
| SAND, silica washed, 100-lb. bag | 60 bg X |
| SHOVEL, molders' square point 9½ by 11⅜ in | 4 ea |
| SILICA, mixture of sand and flour, 100-lb. bag | 1,000 lb X |
| SILICA OF SODA, 30° Baume scale, 100-lb. bag | 200 lb X |
| SPONGE, molders', bulb, 1-pint | 4 ea |

| *Nomenclature* | *Quantity* |
|---|---|
| STICK, gate, straight, 6 x 1 in. | 3 ea |
| STICK, gate, straight, 6 x 1¼ in. | 3 ea |
| STICK, gate, taper, 6 x ½ x 1¼ in. | 3 ea |
| STRIKE OFF, flask | 1 ea |
| SWAB, molders' camel hair, split quill, No. 3 | 4 ea X |
| TOOL, molders', draw pin, 8 in. long | 4 ea |
| TOOL, molders', heart trowel, 2¼ in. wide | 4 ea |
| TOOL, molders', lifter, ¼ x 12 in. | 2 ea |
| TOOL, molders', lifter, ¾ x 12 in. | 2 ea |
| TOOL, molders', slick and oval spoon, ¾-in. width | 4 ea |
| TOOL, molders', square trowel, 1¼ in. x 6 in. | 3 ea |
| TOOL, molders' stove tool No. 1, ⅜ in. wide | 2 ea |
| TOOL, molders', taper and leaf, ¾-in. width | 4 ea |
| TOOL, molders', wood screw, 6½-in. | 4 ea |
| WASH, core formula No. 572, 25-gal. drum | 1 dr X |
| WIRE, vent, 10-in. | 1 ea X |
| WIRE, vent, 20-in. | 1 ea X |

### 3. MELTING

| | |
|---|---|
| ALUMINUM, shot, foundry | 300 lb X |
| BOWL, ladle, flat bottom, welded steel, 60-lb. capacity | 1 ea |
| BRONZE, phosphorus deoxidized, 80-10-10 per cent tin lead | 100 lb X |
| CAPACITOR, foundry equipment, internally water-cooled | 1 st |
| CEMENT, lining patching on coil, 100-lb. bag Norpatch or equal | 500 lb X |
| CHARCOAL, wood | 100 lb X |
| CONTACTOR PANEL, foundry equipment, with 6 contactors arranged for 208-volt, 60-cycle, 3-phase | 1 st |
| CONTROL PANEL, foundry equipment, with switches and push buttons for contactor operation | 1 st |
| CRUCIBLE, formula GHI, with washed special slag lining, No. 70 | 120 ea |
| FERRO MANGANESE, briquet, 80-percent | 1,000 lb X |
| FERRO SILICON, briquet, 50-percent | 1,500 lb X |
| FREQUENCY CHANGER, foundry equipment, motor, 80-hp, 208-volts, 3-phase, 60-cycle induction type, generator, 50-kw, 1-0 power factor, 3,600-rpm, 800-volts, 3,000-cycles | 1 st |

| *Nomenclature* | *Quantity* |
| --- | --- |
| FURNACE, foundry equipment, coil, Lift No. 70 crucible, complete with electrical and water terminals, furnace guides, with hand-operated hoist, crucible truck, etc. | 1 st |
| FURNACE, foundry equipment, spare part coil | 1 ea |
| GENERATOR AND EXCITER PANEL, foundry equipment, with 3,000-cycle ammeter, voltmeter, wattmeter, power factor motor, capacitor voltmeter, line contactor, with overload relay, field switch and field ammeter, voltage regulator and adjusting rheostat | 1 st |
| GENERATOR SET, portable, Diesel engine driven, skid mounted, 60-kw, 127–220-volt, 3-phase, 60-cycle, or 230–400-volt 3-phase, 50-cycle | 1 ea |
| GENERATOR SET, portable, Diesel engine driven, spare parts, field set | 1 st |
| GENERATOR SET, portable, gasoline engine driven, skid mounted, 3-kw, 125-volt, d-c | 1 ea |
| GENERATOR SET, portable, gasoline engine driven, spare parts, field set | 1 ea |
| GLOVES, lineman's leather, heavy, gauntlet | 3 pr |
| GOGGLES, steel makers', O.H. lenses, No. 6, with 12 extra lenses | 2 pr |
| IRON, pig, foundry, cut to 4-in. length | 1,000 lb X |
| MAGNESIUM COPPER, 20–80 percent, shot, foundry | 150 lb X |
| MOLD, ingot, double, 13 x 3½ x 2½ in. | 2 ea |
| MOTOR SWITCH, foundry equipment, with overload protection | 1 st |
| PYROMETER, optical, triple scale | 1 ea |
| PYROMETER, portable, hand type, 0° to 2,500° F. range, 36-in., with extra thermocouple | 1 ea |
| ROD, temperature test, iron ¼ x 6-ft. (approx.) | 50 lb X |
| SCALE, weighing, platform, scoop, counter, platform or scoop weighing, 250-lb. capacity | 1 ea |
| SHANK, crucible, double end, No. 70 crucible | 1 ea |
| SHANK, crucible swivel end, No. 70 crucible | 1 ea |
| SHANK, hand ladle, with fluted cast-steel bank and pipe handle, 50-lb. ladle bowl | 1 ea |
| SKIMMER, with handle, 8-in. diameter, 31 holes, 46 in. long | 1 ea |
| STEEL, scrap, foundry sheared, ¼ to ½ in. thick, 2 to 4 in. wide, 6 to 10 in. long | 400 lb X |

## 4. GENERAL.

| *Nomenclature* | *Quantity* |
|---|---|
| BLADE, hacksaw, hand, flexible, 12-in., 14 teeth | 12 ea X |
| BOOK, reference, Cast Metal Handbook, publication of American Foundryman's Association | 1 ea |
| BOOK, reference, Melting Equipment Bulletin No. 11A, publication of Ajax Electro-Thermic Corp | 1 ea X |
| BROOM, fiber 36 lb. per doz | 1 ea |
| BRUSH, wire scratch, straight back, 5 x 13 rows, 7⅝ x 2⅝-in. block | 2 ea |
| BRUSH, wire scratch, with wood handle, 2 x 19 rows, 14 in. long | 2 ea |
| BUCKET, general-purpose, iron, galvanized, 14-qt | 2 ea |
| CHISEL, machinists', hand, cold, single, ¾-in. bit, ⅝-in. hex., 8 in. long | 1 ea |
| FILE, single, flat, bastard 16 in | 1 ea |
| FILE, single, half round, bastard 12 in | 1 ea |
| FILE, single, round, bastard, 12 in | 1 ea |
| FILE, single, square, bastard 16 in | 1 ea |
| FRAME, hacksaw, adjustable, 8- to 12-in., pistol grip | 1 ea |
| GOGGLES, eyecup, impact resisting, chippers' and grinders', with extra lens | 2 pr |
| GRINDER, electric, bench type, ½-hp, 110-volt, 60-cycle, single-phase | 1 ea |
| HAMMER, machinists', ball peen 1½-lb | 1 ea |
| NAIL, wire steel, foundry, bright, No. 8, 1-in | 25 lb X |
| NAIL, wire, steel, foundry, bright, No. 8, 2-in | 25 lb X |
| NAIL, wire, steel, foundry, bright, No. 8, 3-in | 25 lb X |
| PINCERS, carpenters', 6-in | 1 pr |
| REFRACTORY, foundry equipment, hoppers, rings, shapes, etc. | 2 st |
| RULE, carpenters', 36-in., 4-fold | 1 ea |
| SCREW DRIVER, common, wood handle, 4 in. long x ¼ in. wide blade | 1 ea |
| SCREW DRIVER, common, wood handle, 8 in. long x ⅜ in. wide blade | 1 ea |
| SCREW DRIVER, rachet, spiral 14 in. long (closed) | 1 ea |
| SHIELD, face, fitted with 6-in. plastic window and 6 extra windows | 2 ea |

| *Nomenclature* | *Quantity* |
|---|---|
| SQUARE, machinists', combination, with center head and bevel protractor, 12-in. blade | 1 ea |
| STONE, sharpening, round edge slip, 1/8- x 1/4-in. edge, 1 3/4 in. wide, 4 1/2 in. long | 2 ea |
| STONE, sharpening, round edge slip, artificial 3/8- x 1/2-in. edge, 2 1/8 in. wide, 4 1/2 in. long | 2 ea |
| STONE, sharpening, unmounted, combination, one side coarse other side fine, 1 in. thick, 2 in. wide, 8 in. long | 1 ea |
| WHEELBARROW, general utility, steel tray, steel handles 3 cu. ft | 1 ea |

## APPENDIX IV

# TRAINING

*(MTP 5–1)*

Specialist training for the men of engineer foundry units is divided into five courses according to the following tentative outline:

### MOLDER

| | Hours |
|---|---|
| Orientation | 4 |
| Nomenclature | 3 |
| Sands | 8 |
| Patterns | 13 |
| Use of equipment | 31 |
| Construction of molds | 173 |
| Pouring | 37 |
| Field expedients | 31 |
| Total | 300 |

### FURNACE OPERATOR

| | |
|---|---|
| Orientation | 2 |
| Nomenclature | 3 |
| Care and maintenance of equipment | 63 |
| Assembly and disassembly of equipment | 22½ |
| Metals and pouring temperatures | 182½ |
| Field expedients | 22 |
| Total | 300 |

### PATTERNMAKER

| | |
|---|---|
| Orientation | 2 |
| Nomenclature | 8 |
| Blueprint reading, measurements, and layouts | 70 |
| Wood for patterns | 4 |
| Use and care of machines and hand tools | 18 |
| Construction of patterns and core boxes | 184 |
| Marking of patterns and core boxes | 4 |
| Field expedients | 10 |
| Total | 300 |

## CORE MAKER

| | Hours |
|---|---|
| Orientation | 2 |
| Nomenclature | 3 |
| Sands | 4 |
| Sand binders | 4 |
| Mixing core sand | 37 |
| Core boxes | 20 |
| Making cores | 189 |
| Baking cores | 10 |
| Finishing cores | 21 |
| Field expedients | 10 |
| Total | 300 |

## CASTING FINISHER

| | |
|---|---|
| Orientation | 2 |
| Nomenclature | 6 |
| Tools and equipment | 16 |
| Sandblasting | 22 |
| Chipping | 71 |
| Grinding | 88 |
| Filing | 5 |
| Stoning | 2 |
| Removing gates and risers with torch and saw | 51 |
| Heat treating of steel | 35 |
| Field expedients | 10 |
| Total | 300 |

# APPENDIX V
## RECORDS

There are no standard War Department forms for keeping foundry records and each unit may improvise its own. The following samples have been found helpful and may serve as a guide. Each foundry officer and foreman should see that records are kept accurately and up to date.

JOB ORDER TO ENGINEER HEAVY SHOP
MANUFACTURING SECTION

DATE 15 March 1944 PRIORITY NO 1 JOB ORDER NO. 67xx
FROM Heavy Shop Technical Section
REQUESTED BY Major Eugene L Davis PER Lt. M. C. Harmon
PHONE NO.

CLERK'S NAME Sgt Sarno
ARTICLE Rail Bearing Cover
DESCRIPTION OF WORK

Make (1) Pattern (As per drawing No. 470)
Cast (8) Rail Bearing Covers in Bronze (As per pattern)

TIME

MATERIAL USED

8 Castings delivered to the Machine Shop 3/17/44
Total Weight 12 lbs.

O. K BY Lt. M. C. Harmon
DATE FINISHED 3/17/44
COMPLETED WORK IN BIN NO.

REC'D BY Major Eugene L. Davis
COMPANY Hvy Shop Tech Sect
DATE REC'D 3/16/44

*Figure 51. Job order form.*

## JOB ORDER RECORD

FOLIO NO.________

| LINE NO. | REQUEST NO. | JOB ORDER NO. | DATE ORDER ISSUED | DATE ORDER PROMISED | DATE ORDER FINISHED | DESCRIPTION OF ARTICLE |
|---|---|---|---|---|---|---|
| 1 | 200 | 67xx | 3/16/44 | 3/17/44 | 3/17/44 | 8 Rail Bearing Covers (No 470) Bronze Heavy Shop Technical Section - Maj Davis |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | | | | | | |
| 13 | | | | | | |
| 14 | | | | | | |
| 15 | | | | | | |
| 16 | | | | | | |
| 17 | | | | | | |
| 18 | | | | | | |
| 19 | | | | | | |
| 20 | | | | | | |
| 21 | | | | | | |
| 22 | | | | | | |
| 23 | | | | | | |
| 24 | | | | | | |
| 25 | | | | | | |

*Figure 52. Job order record.*

Rail Bearing Cover JOB ORDER NO 67xx

FOR Heavy Shop Technical May Davis PHONE NO. ______

METAL Bronze WT. 1½ lbs

NO. ORDERED 8 NO SHIPPED 8 TOTAL WT. 12 lbs

HEAT NO. 347 MOLDED BY J-5 Padgett

PRINT NO. 470 PATTERN NO. 1-105 CORE BOX NO None

LOCATION OF PATTERN & CORE BOX Section 1 Shelf 4

DESCRIPTION OF MOULDING & POURING Albany Sand

TOTAL WEIGHT PER CASTING
HEADS, ETC. 45#

*Figure 53. Casting record card.*

PATTERN NO. 1-105

LOCATION: Section 1, Shelf 4

CUSTOMER: Heavy Shop Technical Section

DRWG NO: 470

JOB ORDER NO'S: 67xx

*Figure 54. Pattern record card.*

HEAT NO: 347

DATE: Mar 17, 1944

SHIFT: A

MELTING LOG

| CHARGE | | |
|---|---|---|
| MATERIAL | WT. | APPROX. ANALYSIS |
| Scrap Bronze | 150# | 80-10-10 |
| | | |
| | | |
| | | |
| | | |
| | | |

| POWER | | | |
|---|---|---|---|
| | TIME | | |
| START | 1015 | | |
| STOP | 1100 | | |
| TOTAL | 3/4 hr. | | |

TAP TEMP. 1900°F

CRUCIBLE NO. 6 HEAT NO. 15

CASTINGS POURED: Bushings (5)

Tail Bearing Covers (8)

| ADDITIONS | | |
|---|---|---|
| MATERIAL | WT. | % ADDITION |
| Zinc | 1½# | 1% |
| | | |
| | | |
| | | |

COMMENTS:

DESIRED FINAL ANALYSIS:

MELTER T/4 Murphy

*Figure 55. Melting log.*

## DAILY MAINTENANCE CHART

## DIESEL - GENERATOR SET

DATE *March 17, 1944*

| BEFORE STARTING CHECK FOLLOWING | SHIFT *A* <br> TOTAL RUN TIME TO DATE *596 ½* HOURS | |
|---|---|---|
| | REMARKS | SIGNATURE OF CHECKER |
| 1. COOLING SYSTEM | Add Soft Water as Necessary | *Tec. 4 Murphy* |
| 2. CRANKCASE | Check Oil Level on Dip Stick. Keep Oil between LOW and FULL | *Tec. 4 Murphy* |
| 3. FUEL OIL FILTERS | Drain ¼ pt. of Fuel Oil From Primary and Secondary Filters | *Tec. 4 Murphy* |
| 4. FUEL TANK | Check Fuel Oil Level. Do Not allow Tank to become Empty | *Tec. 4 Murphy* |
| | | |

### LOG OF OPERATION

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| TIME START | *0815* | *1300* | | | | | | | |
| TIME STOP | *1100* | *1645* | | | | | | | |
| HOURS RUN | *2 ¾* | *3 ¾* | | | | | | | |
| TOTAL HOURS RUN: | *6 ½* | | | | | | | | |

NOTE Check Total Hours Run Time for periodic Maintenance and Lubrication

REMARKS *Performance OK*

SIGNATURE *Tec. 4 Murphy*

*Figure 56. Maintenance record form.*

## FOUNDRY PRODUCTION REPORT FOR Sept. & Oct. 1-15

| CUSTOMER | TYPE OF CASTING | TYPE OF METAL | WEIGHT |
|---|---|---|---|
| 705th Pet. Dist Unit | Lower Gin Pole Knuckle | Cast Iron | 210# |
| " " " " | Upper Gin Pole Knuckle | Cast Iron | 140# |
| " " " " | Chain Housing | Cast Iron | 204# |
| " " " " | Housing | Cast Iron | 36# |
| | | | 590# |
| 725th Ry. Op. Bn. Co B | Tender Steps | Cast Iron | 1100# |
| " " " " " " | 81 Bronze Bushings | Bronze | 180# |
| " " " " " " | Draw Bar Bracket | Cast Iron | 1500# |
| " " " " " " | Piston Glands | Cast Iron | 144# |
| " " " " " " | Valve Stem Packing Gland | Cast Iron | 93# |
| " " " " " " | Bronze Bushing | Bronze | 314# |
| " " " " " " | Bronze Bushing | Bronze | 17# |
| " " " " " " | Bronze Bushing | Bronze | 16# |
| " " " " " " | Diesel Engine | Aluminum | 2# |
| | | | 3366# |
| 797th & 798th Forestry Company | Saw Handles | Aluminum | 10# |
| Machine Shop H. S. T. S. | Rope Starter Pulleys | Aluminum | 26# |
| " " " | Gears For Printing Machine | Cast Iron | 95# |
| " " " | Caps | Cast Iron | 35# |
| " " " | Clutch Gears | Cast Iron | 60# |
| " " " | V Blocks | Cast Iron | 68# |
| " " " | Guard For Lathe Bed | Cast Iron | 29# |
| " " " | Guard For Lathe Bed | Aluminum | 8# |
| | | | 321# |
| Post Engrs | Pulley | Cast Iron | 40# |
| | Plates | Cast Iron | 96# |
| | | | 136# |
| Center Engrs | Grates | Cast Iron | 264# |
| Camp Polk | Sprocket Wheel | Cast Iron | 476# |
| Foundry Heavy Shop | Al Alloy Pigs | Aluminum | 2000# |
| " " " | Blower Housing | Cast Iron | 86# |
| " " " | Castings | Aluminum | 70# |
| " " " | Match Plate | Aluminum | 19# |
| " " " | Weights | Cast Iron | 1060# |
| | | | 3235# |
| Total Wt. Cast Iron | | | 5836# |
| Total Wt. Aluminum | | | 2135# |
| Total Wt. Bronze | | | 527# |
| | | | |

*Figure 57. Production report form.*

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